MOBILITYPLAN 2050

Appendix K

Travel Demand Model Summary

Contents

Travel Demand Model Performance Summary

After finalizing the fiscally constrained project list, the TPO's regional travel demand model was used to assess the performance of the transportation system with and without the projects. A comparison of common transportation system performance metrics are provided in Table X, both in the base year and the final horizon year of the Mobility Plan, which is 2050. For the year 2050 two separate scenarios were run in the model – one using the roadway network as it existed in 2022 and the other using the roadway network with all of the fiscally constrained road projects being implemented. This allows us a glimpse into what the future might look like if the population and employment growth expected in the TPO Region between now and 2050 all showed up overnight.

Travel Demand Model Output Statistics - 2050 Mobility Plan for TPO Planning Area

Performance Metric	2022 Base Year	2050 (Base Network)	2050 (Mobility Plan Projects)	% Change from 2022	% Change 2050 Scenarios
Population Estimate	756,349	913,935		20.8%	
DVMT (veh-miles per day)	20,011,194	23,842,698	24,691,675	23.4%	3.6%
DVHT (veh-hours per day)	511,166	657,086	645,228	26.2%	-1.8%
Daily Avg Speed (mph)	39.1	36.3	38.3	-2.2%	5.5%
Hours of Delay (hours per day)	119,433	188,164	165,644	38.7%	-12.0%
Percent Time Congested	16.3%	18.8%	17.6%	7.9%	-6.4%
VMT at LOS F	5,301,754	9,130,401	8,004,330	51.0%	-12.3%

An explanation of the metrics that were compared are as follows:

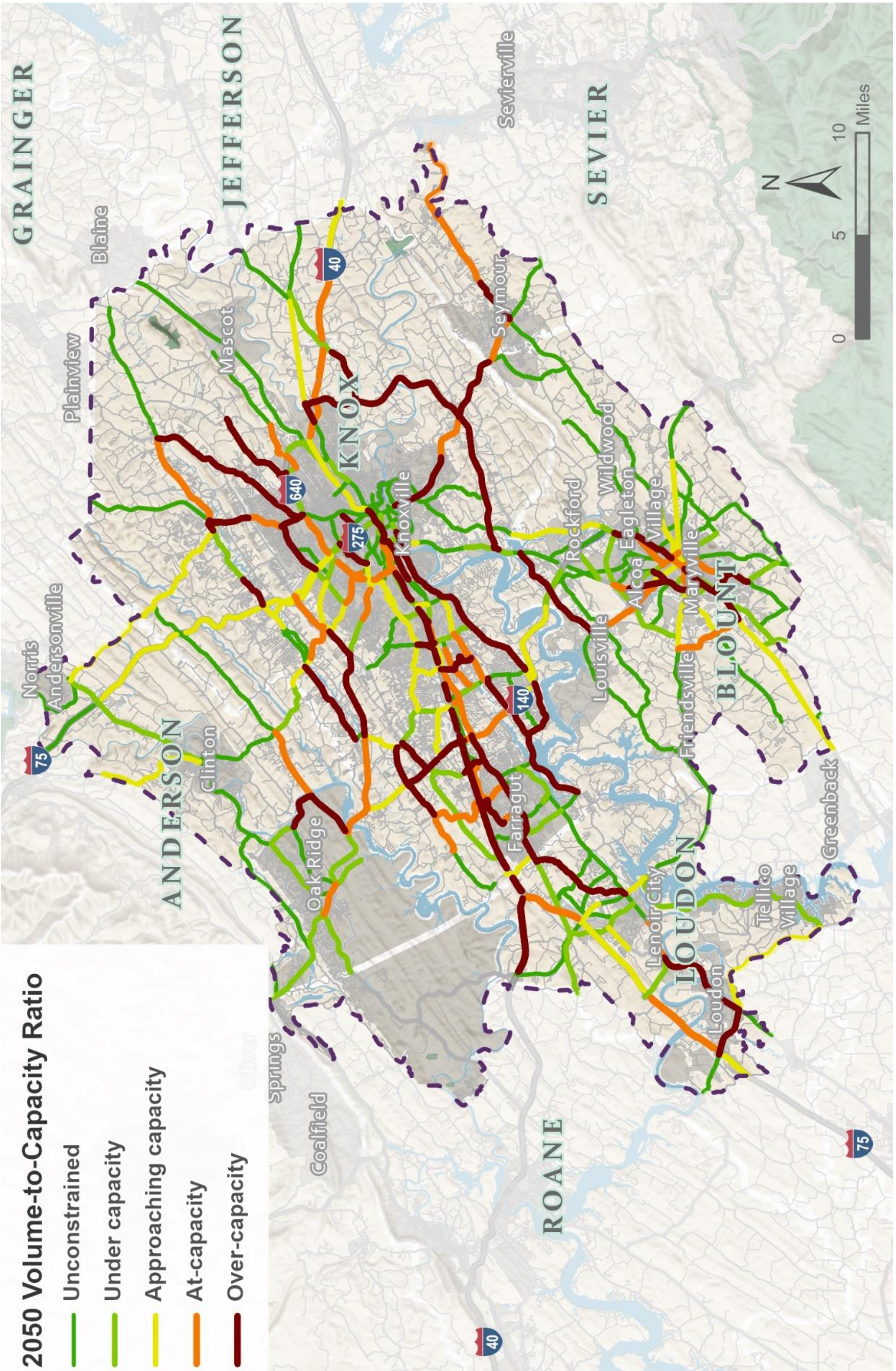
- Daily Vehicle Miles Traveled (DVMT) – This is a measure of total amount of vehicular travel on the regional roadway system on an average day. It is computed by multiplying the volume of traffic on a roadway segment by its length.
- Daily Vehicle Hours Traveled (DVHT) – Similar to DVMT, this is the total time spent by vehicles operating on regional roadways on an average day.
- Daily Average Speed – This is computed by dividing DVMT by DVHT and can provide an indication of operating efficiency or overall congestion.
- Hours of Delay – This is a metric computed from post-processing the travel demand model outputs and aggregating travel times where actual speed is less than the free-flow speed.
- Percent Time Congested – Also a metric computed by the model as a function of the overall time per day that vehicles experience poor "Level of Service" conditions indicating congestion.
- VMT at LOS F – This is a measure of the vehicle travel that occurs on roadway segments that are expected to operate at the poorest level-of-service, another indicator of congestion levels.

Therefore, the metrics shown in Table X indicate how efficiently the roadway system within the TPO's planning area operates with the planned project investments. It can be observed however that even with the implementation of all the fiscally constrained projects that the expected increase in travel activity from the higher population and employment will likely result in more delay and congestion in the year 2050 than was present in 2022. Some of the major takeaways are as follows:

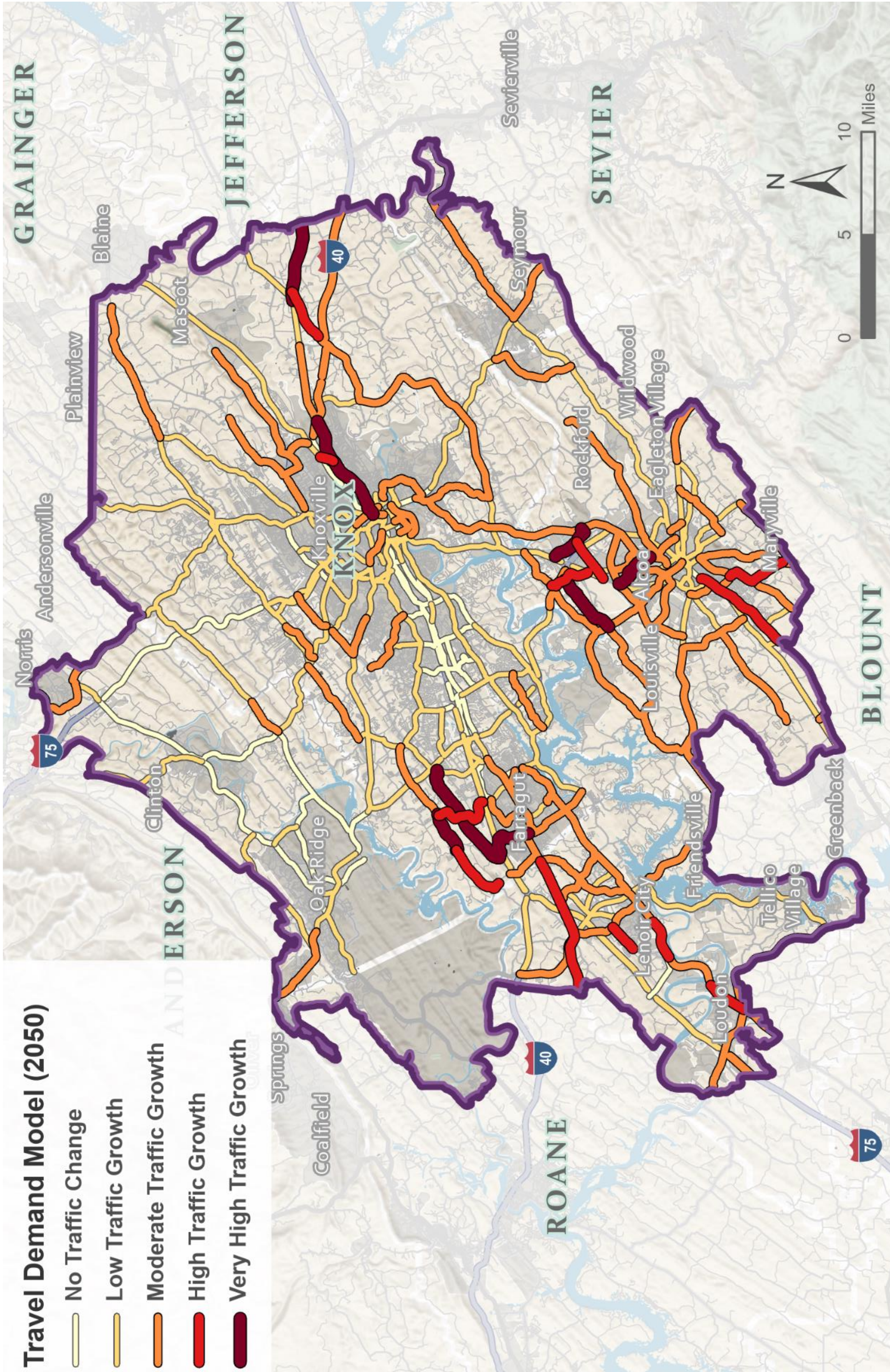
- Vehicle Miles Traveled is expected to outpace the growth in population, which can be an indicator of the continued dispersed development patterns of population and employment in the Region leading to longer average trip lengths.
- Delay and Congestion both increase significantly in the future although the project implementation is shown to be very beneficial as metrics such as the VMT on roadways with level-of-service F rating and Hours of Delay are both around 12% less in the "build" versus "no-build" scenario.

The travel demand model was also an important <u>tool used to evaluate</u> each roadway's congestion level in order to help target those that are <u>most congested for potential improvement projects</u>, for more information see Appendix D for the Congestion Management Process (CMP). It is important to note that the travel demand model is ***<u>not able to account for</u>*** improvements to the transportation system generated by projects that do not increase roadway capacity (e.g., greenway, sidewalk, transit, or bikeway projects) but these are also critical to achieving efficient mobility in light of constraints both fiscally and environmentally along with other impacts from major roadway construction.

V/C for FY 2050 network



Change in V/C between FY2050 – BY2022 networks



Knoxville Regional Travel Model 2022 Base Year Update – Development of Traffic Analysis Zone (TAZ) Socioeconomic Data and Roadway Network

Final

9/30/2024

Contents

List of Tables and Figures

I. Introduction

The purpose of this document is to provide details of the development of the updated base year socioeconomic data and transportation (roadway) network to represent year 2022 conditions for the Knoxville Regional Travel Demand Forecasting Model (KRTM). This update effort is being undertaken to support the regular 4-year update of the Metropolitan Transportation Plan (MTP) for the Knoxville Regional TPO Planning Area, known as Mobility Plan 2050. These elements are both integral to meeting federal transportation planning regulations (23 CFR 450.324) that state, in part – "In updating the transportation plan, the MPO shall base the update on the latest available estimates and assumptions for population, land use, etc.".

The remainder of this document is organized into two main sections - one covering the development of population, demographics and employment (collectively known as 'socioeconomic characteristics') for the base year (2022) Traffic Analysis Zone system (TAZ) as well as establishing future-year county level control totals for population and employment; and the other section covering the travel demand forecasting model 2022 base year roadway network update.

II. Socioeconomic Data

With each update of the MTP, it is important to establish an updated base year in which all necessary data is available for the attributes required to run the KRTM. This process also involves the formal establishment of future-year control totals of the key variables of population and employment through a review of previous forecasts to ensure that they are: (1) still valid and relevant and (2) if they need to be extended further into the future to match the MTP's updated horizon year. In the case of the Mobility Plan2050, it was determined that 2022 should be the base year since that was the most recent year with full data availability when the MTP development started in late 2023 and the population/employment forecast would need to be extended from the latest year available of 2045 in the previous MTP out to 2050. The year 2050 was chosen in order to cover the minimum required 20-year horizon beyond the adoption date of the new MTP in 2025.

BACKGROUND ON KRTM AND TAZ ATTRIBUTES

In order to project future conditions of the roadway system the TPO uses a computer-modeling tool known as a travel demand forecasting model. The Knoxville Regional Travel Demand Model (KRTM) is calibrated to closely replicate existing traffic patterns in the Knoxville Region to provide a means of forecasting future traffic volumes and resulting areas of potential congestion. It is also used to support the air quality conformity analysis that is required for the Knoxville Region since it is an air quality Maintenance Area for both Ozone and PM2.5. The model covers the primary roadway network in a 10-county area that includes Anderson, Blount, Grainger, Hamblen, Jefferson, Knox, Loudon, Roane, Sevier, and Union counties. To develop the model, mathematical relationships between travel activity and household socioeconomic characteristics were derived from extensive travel behavior surveys that were conducted in the years 2000 and 2008. In these surveys, approximately 3,000 households in the Knoxville Region were asked to record their travels in a one-day period including:

- Purpose of the trip
- Origin and destination of each trip
- Mode of transportation used
- Time of day trip was made

The model was developed based on the assumption that households with similar socio-economic characteristics such as household income, number of school-age children, and vehicle ownership would demonstrate similar travel activity. These household characteristics are available primarily from the U.S. Census Bureau and are input into the model based on their distribution across TAZs the Knoxville Region.

The current model has its origins back to 2012 when an update was completed to calibrate and validate the model using 2010 Decennial Census data. Since that time three minor updates have been completed – one for the prior Mobility Plan 2040 and Mobility Plan 2045 and one now for Mobility Plan 2050. In those minor updates the model has been validated against new base years of available data – 2014, 2018 and 2022 respectively. A major model update is being planned for the next Mobility Plan following this one since a major new household travel behavior survey is anticipated to be conducted in Spring 2025 and will not be available prior to this Plan adoption.

Table 1 on the following page provides an explanation of the data fields in the TAZ geographic file:

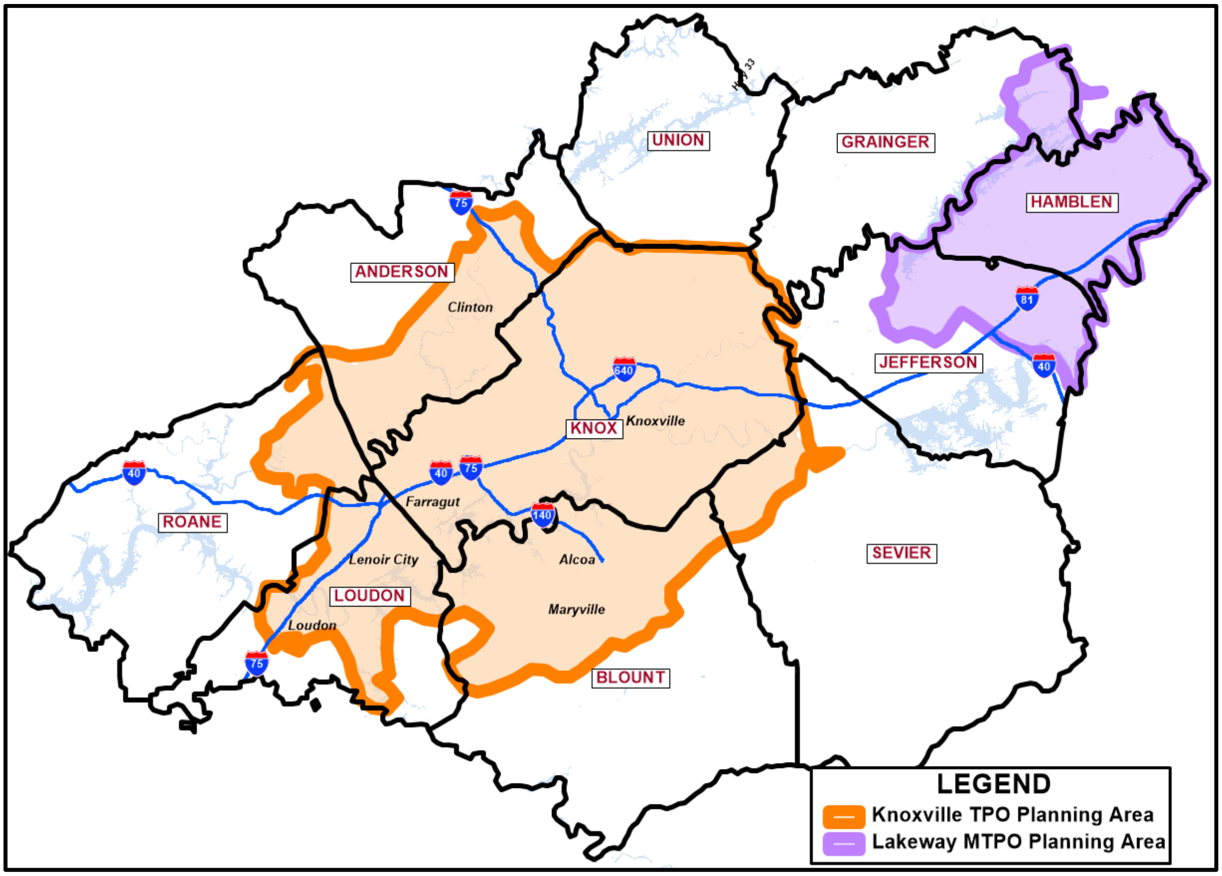
Table 1 – TAZ Attributes

Field Name	Description
TAZID	Unique ID
Area	Area of TAZ in sq. miles
CO_NAME	County Name
TOTPOP	Total Population
HHPOP	Population in Households
GQPOP	Population in Group Quarters
HH	Number of Households
AVGHHSIZE	Average Household Size
AVG_MEDHHINC	Average Median HH Income
WRKR_PER_HH	Workers per Household
STD_PER_HH	Students per Household
PCT_HH_W_SR	Percent of HH with Senior (65+)
Enroll_K12	K-12 School Enrollment
Univ_Stdnts	UT Student Residence Location
UNIV_ENROLL	College/University Enrollment
Basic Emp	Basic Employment
Industrial Emp	Industrial/Manufacturing Employment
Retail Emp	Retail Employment
Service Emp	Service Employment
Total Emp	Total Employment

POPULATION

The amount of travel activity in the Knoxville Region is directly related to the number of people living here, which is why it is important to establish the base year and future year population totals as a first step in each major update of the MTP. The official Planning Area boundaries of the Knoxville Regional TPO include portions of six counties including Anderson, Blount, Knox, Loudon, Roane and Sevier. Additionally, the TPO's travel demand model includes four other counties of: Grainger, Hamblen, Jefferson and Union for which population data is required. The travel demand model is also used to support the MTP update for the separate Lakeway Area Metropolitan Transportation Planning Organization (LAMTPO) which includes all of Hamblen County and a large portion of Jefferson County plus a small part of Grainger County. The entire study area along with the planning area boundaries of the Knoxville Regional TPO and LAMTPO are shown in Figure 1.

Figure 1 - Travel Demand Model Study Area



The population totals for each of the ten counties were obtained for the base year 2022 from the U.S. Census "Population Estimates Program" which are released on an annual basis and represent the estimated county-level population as of July 1 for the reference year. The future year 2050 population forecast for each county were selected through a process of reviewing two primary sources of population projection data – "2018 – 2070 Projections" from the University of Tennessee (UT) Center for Business & Economic Research (CBER) and "2023 Regional Projections" from Woods & Poole, Inc. (W&P). Following the review of the two sources, the TPO staff recommended using the W&P source for the population forecasts as it is similar to CBER's forecast for population changes and it also provides projections for several other needed socioeconomic variables. The TPO Executive Board endorsed the staff recommendation of W&P as the source for future year county-level population forecasts at its April 24, 2024 meeting. Table 2 provides the 10-county population totals for the base year 2022 and future years of 2030, 2040 and 2050 to support the Mobility Plan 2050 development and travel demand model.

Table 2 – Population Forecasts

County, Population	2022[1]	2030[2]	2040[2]	2050[2]
Anderson	78,913	81,214	83,170	84,591
Blount	139,958	150,620	163,105	175,416
Grainger	24,277	25,115	26,202	27,337
Hamblen	65,168	67,885	70,579	72,878
Jefferson	56,727	60,473	64,714	68,779
Knox	494,574	525,477	559,996	592,702
Loudon	58,181	63,414	69,770	76,239
Roane	55,082	56,264	57,079	57,511
Sevier	98,789	108,778	121,217	134,155
Union	20,452	21,166	22,094	23,062
Total	**1,092,121**	**1,160,406**	**1,237,926**	**1,312,670**

1 - From Census Annual County Population Estimates data series, 2022 vintage (as of July 1, 2022)

2 - From Woods & Poole Economics, 2023 Regional Projections and Database

The population forecasts for the Mobility Plan 2050 update are representative of a few competing recent trends affecting population change such as the continuation of overall declining birth rates and a recent increase in mortality likely due to the COVID-19 pandemic leading to reduced population, but these effects are balanced by the relatively high amount of net positive in-migration to the State of Tennessee and Knoxville Region leading to overall positive expected population growth.

In terms of disaggregating the county-level population control totals shown in the table above to the KRTM TAZ-level, the TPO staff utilized a product from the company Applied Geographic Solutions (AGS) known as the "Estimates and Projections" database which provided all variables needed for the 2022 base year at the smallest census geography of Census Blocks. The AGS data specifically corrects for new Census privacy and disclosure proofing that creates intentional errors at small geographic scales. AGS has several blog posts such as this **one** regarding implausible Census data that can show phenomena like "ghost communities" where there are Census Blocks showing occupied dwellings with zero population. The full AGS methodology is available at their website **here**.

EMPLOYMENT

In addition to population, another important variable influencing travel, and in particular the specific areas where travel occurs, is the amount of employment in the Knoxville Region. The locations of employment (jobs) represent trip attractions for both the basic need of the worker to be at their place of work as well as locations where commerce or other necessary daily activities such as grocery shopping or attending medical appointments occur. The TPO travel demand model categorizes employment into four major types of: Basic (farming, construction), Industrial (manufacturing, wholesale trade), Service (professional, educational services) and Retail (shopping, accommodation, food services) since each type exhibits significantly different characteristics in the type of trips generated. For example, retail employment tends to attract trips from workers as well as patrons whereas industrial employment will attract primarily worker trips as well as commercial vehicle (truck) trips to distribute finished or unfinished goods.

Unlike population, there is not necessarily a definitive source of the amount of employment in each county that is enumerated as with the decennial Census. Two primary sources of employment data come from the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS). In general, the BEA estimate of employment produces a significantly higher number of jobs than the BLS estimate for the same county. The BLS employment estimates are lower in part because agricultural workers, the military, sole proprietors and other miscellaneous workers are excluded. The manner in which proprietorship employment is treated appears to account for the largest difference in terms of the BEA versus BLS estimates for the Knoxville Region since there are no large military bases or significant amount of farm employment. For example, the BEA (and W&P) employment estimates will double-count a person who has a full-time salary job and in their “spare” time (nights/weekends) runs a small business (proprietorship) from their home.

After reviewing the data sources, the TPO staff developed a modified estimate of total county-level employment utilizing a combination of the BEA and BLS estimates at the 2-digit NAICS code level (see Appendix A for documentation of the factors that were applied to each category). The county-level totals derived using this combination compared favorably with the summation of individual establishment-level employment data that was obtained through the Tennessee Department of Transportation (TDOT) from the company known as InfoGroup that is described further in Appendix A. Since the base year 2022 employment derived by this method is lower than the W&P employment that is used to provide future-year employment projections, the TPO staff applied a growth factor from W&P to each of the future analysis years out to 2050 as shown in Table 3. Additionally, Table 4 shows the effects of the differing growth rates of employment by the major sectors previously documented of: Basic, Industrial, Retail and Service that continue the historical trends towards fewer manufacturing and similar job categories compared with more jobs in the retail and service sectors.

Table 3 - Employment Forecasts

County, Employment	2022[1]	2030[2]	2040[2]	2050[2]
Anderson	49,750	51,281	53,413	54,834
Blount	66,473	75,592	87,766	101,240
Grainger	6,760	7,029	7,450	7,834
Hamblen	38,475	40,477	42,718	44,869
Jefferson	19,139	20,727	23,005	25,356
Knox	306,232	339,499	381,864	424,343
Loudon	22,555	24,118	26,987	30,001
Roane	24,296	25,820	27,538	28,913
Sevier	62,834	72,500	85,817	100,899
Union	4,477	5,035	5,719	6,502
Total	**600,989**	**662,078**	**742,277**	**824,791**

1 - Developed from an adjustment of Bureau of Economic Analysis (BEA) and Bureau of Labor Statistics (BLS) employment data

2 - From Woods & Poole Economics, 2023 Regional Projections and Database - used percent growth to generate projection factor for 2022 base year

Table 4 - Employment Forecast by Sector

Employment Sector	2022	2030	2040	2050	Growth% (2022-2050)
Basic	51,347	50,159	50,913	51,710	2.4%
Industrial	102,896	102,045	104,316	106,294	4.6%
Retail	138,946	152,873	169,362	186,009	32.2%
Service	307,800	357,001	417,686	480,778	53.0%
Total	**600,989**	**662,078**	**742,277**	**824,791**	**35.9%**

SCHOOL ENROLLMENT

Updated school enrollment data for 2022 for both public and private schools throughout the 10-county travel demand model study area was obtained through the National Center for Education Statistics (NCES). The base year 2022 enrollment data was compared against the year 2022 estimated school-age (5-17) population count from the W&P data source and found to be in very good agreement. Therefore, the growth rate from the projected W&P data was applied to 2022 base year enrollment in order to develop the future-year projections at the county level as shown in Table 5:

Table 5 - School (K-12) Enrollment Forecasts

County, K-12 Enrollment	2022[1]	2030[2]	2040[2]	2050[2]
Anderson	12,303	11,838	11,718	11,751
Blount	19,008	19,826	20,454	22,302
Grainger	3,112	2,862	3,013	3,189
Hamblen	10,620	10,179	10,034	10,521
Jefferson	7,550	7,254	7,814	8,611
Knox	69,922	72,992	79,374	84,953
Loudon	7,394	7,086	7,467	8,249
Roane	7,805	7,353	7,366	7,435
Sevier	14,931	15,450	17,420	19,911
Union	2,869	2,576	2,676	2,794
Total	**155,514**	**156,347**	**167,243**	**179,716**

1 – National Center for Educational Statistics

2 - Growth rates applied from Woods & Poole Economics, 2023 Regional Projections and Database

DEMOGRAPHIC VARIABLES

The regional travel demand model utilizes average socioeconomic and other demographic variables to inform some travel behavior characteristics that differentiate one household type from another. The key variables used in the model that have been found to have statistically significant effects on trip making either directly or indirectly are: Median Household Income, Percent Households with Seniors (age > 65), Workers per Household and Students per Household. These variables were all updated utilizing the AGS product described previously in addition to the most current 5-year American Community Survey (ACS) data from 2018-2022, which is available at the Block Group level. Note, the Vehicles per Household variable is derived from a vehicle ownership model.

These types of demographic variables can be extremely challenging to forecast for out-years of the planning horizon at the sub-county level and most are used in terms of percentages and ratios, so they do not represent a specific number. Based on that fact, and In keeping with past practice, these variables with the exception of Percent Households with Seniors and Students per Household are left constant for all forecast years except in cases where it is known that a TAZ is experiencing major new greenfield developments or gentrification that are expected to significantly change existing TAZ characteristics. In these cases, the attributes from a similar existing TAZ are borrowed. In terms of the Senior Households variable, there is a known “aging of the population” phenomenon that is also exhibited in the W&P forecasts of the Senior population and its percentage of total county population. Table 6 shows the county-by-county rates of increase of Senior population and these are applied as factors uniformly across the TAZs in each specific county. Similarly, along with overall aging population it would be expected that the number of students per household would decrease. Table 7 shows the county-by-county rates of change for Students per Household.

Table 6 – Senior Population (Age 65 years and older) Percentage of Total Population Forecast

County, % Senior Population	2022	2030	2040	2050
Anderson	21.9%	25.9%	28.3%	29.8%
Blount	22.1%	26.1%	28.1%	27.4%
Grainger	22.6%	26.2%	28.5%	26.9%
Hamblen	19.3%	22.4%	25.0%	25.4%
Jefferson	22.1%	26.3%	28.5%	26.9%
Knox	17.0%	19.4%	19.8%	19.6%
Loudon	28.7%	32.9%	35.5%	35.7%
Roane	25.1%	29.2%	31.2%	30.8%
Sevier	21.7%	25.5%	26.8%	25.2%
Union	20.1%	24.7%	26.5%	25.3%

Table 7 - Students per Household Forecast

County, Students per HH	2022	2030	2040	2050
Anderson	0.36	0.33	0.32	0.32
Blount	0.35	0.31	0.31	0.32
Grainger	0.33	0.29	0.29	0.30
Hamblen	0.41	0.37	0.36	0.37
Jefferson	0.35	0.31	0.32	0.33
Knox	0.36	0.34	0.35	0.36
Loudon	0.33	0.29	0.28	0.28
Roane	0.31	0.28	0.27	0.28
Sevier	0.35	0.32	0.33	0.34
Union	0.38	0.32	0.32	0.32

TAZ ALLOCATION

To this point the focus has been on the county-level basis for the needed variables, which are termed as the “Control Totals” when considering the forecasted values. The KRTM needs inputs of these variables to be allocated to much smaller levels of geography known as Traffic Analysis Zones (TAZ). There are tradeoffs between the size of TAZ and the amount of confidence one can have in allocating future growth and the overall level of detail in the model. In general, the amount of TAZs is directly proportional to the level of detail of the roadway network as roadways generally form the boundaries of a TAZ. In a previous minor update of the KRTM, the number of TAZs was increased from 1,153 to 1,173 with the addition of greater roadway network detail in the LAMTPO Region of Hamblen and Jefferson counties. Knox County has the greatest number of TAZs at 508.

To allocate the future growth of population and employment from the county control total amounts to the smaller TAZs, the TPO staff consulted with planning staffs and stakeholders from each jurisdiction within the TPO and LAMTPO area. Information on locations of proposed developments and other likely development areas of the various jurisdictions was obtained to inform the allocation and then subsequently reviewed with stakeholders to determine the overall reasonableness. This exercise is inherently challenging due to the unforeseen things that can influence development patterns, but should provide a "best guess" that represents current knowledge and can be updated as needed to account for major changes with each subsequent Mobility Plan 4-year update cycle. Table 8 shows the amount of total population and employment increase for each county between 2022 and 2050 that must be allocated to the TAZs and Appendix D includes maps showing the general distribution of population and employment growth:

Table 8 - Population and Employment Allocation by County

2022- 2050 Allocation	Population	Employment
Anderson	5,678	5,084
Blount	35,458	34,767
Grainger	3,060	1,074
Hamblen	7,710	6,394
Jefferson	12,052	6,217
Knox	98,128	118,111
Loudon	18,058	7,447
Roane	2,429	4,618
Sevier	35,366	38,066
Union	2,610	2,026
Total	**220,549**	**223,802**

III. Model Roadway Network Data

ROADWAY NETWORK BACKGROUND

As previously mentioned, the KRTM is a mathematical representation of reality and its backbone in terms of inputs are the roadway network attributes and the socioeconomic characteristics at the Traffic Analysis Zone (TAZ) level.

The roadway network is represented in a Geographic Information System (GIS) as a system of links and nodes. Each link in the model represents a segment of roadway that is described by several attributes, including:

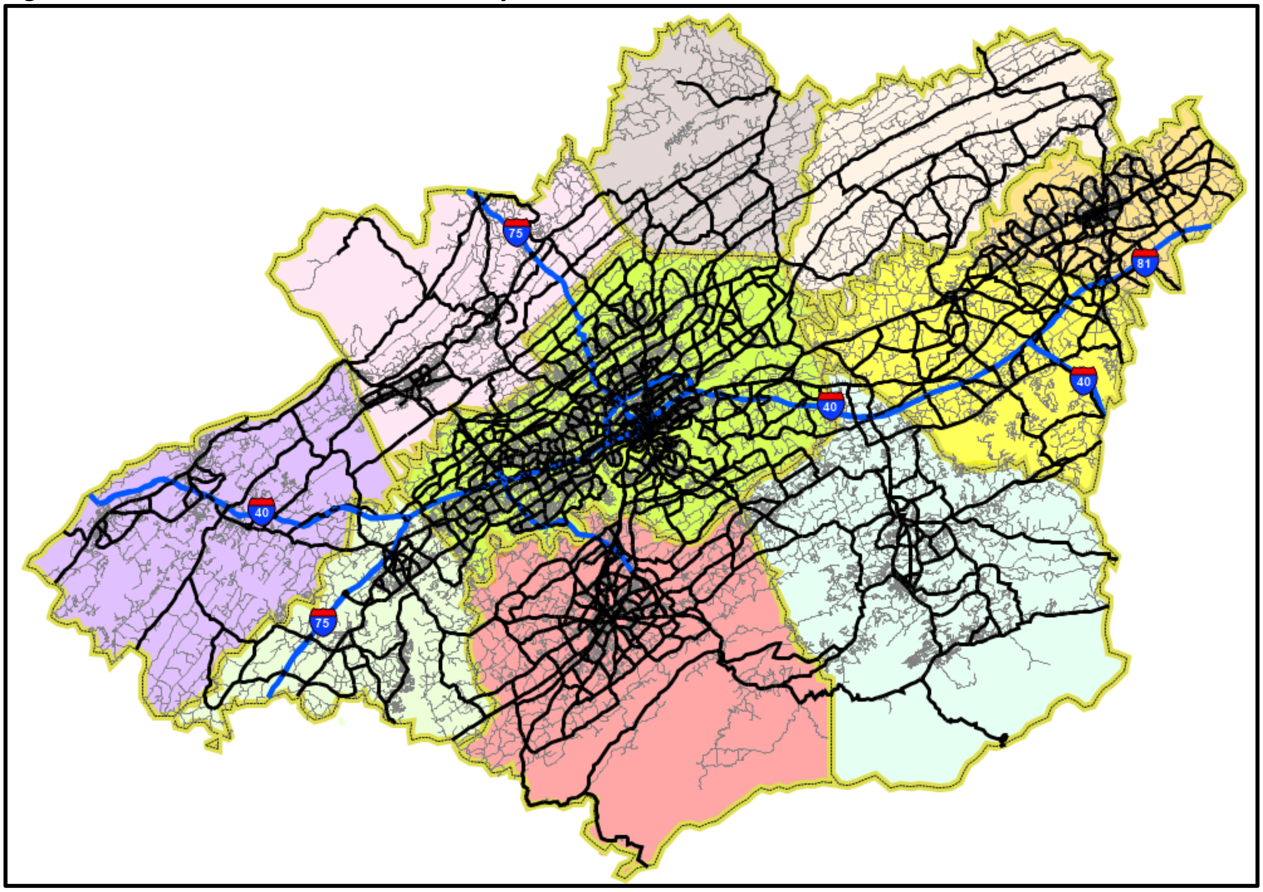
- Functional classification
- Speed limit
- Number of lanes
- Pavement width
- Level of access control
- Whether it is divided by a median

The Nodes represent intersections, locations of traffic signals, and places where roadway characteristics might change in the middle of a segment (such as where a road narrows). Roadway attributes are used to determine the vehicular capacity and travel time along each link in the model network. The model can therefore be used to test alternative improvement strategies by changing appropriate attributes such as increasing the number of lanes or by coding in a new link to represent construction of a new roadway.

In addition to the roadway attributes several other reference fields are coded into the roadway network including the actual traffic counts where available. Traffic counts are conducted on an annual basis by both TDOT and the Knoxville TPO and are important in being able to validate and ground-truth the model to ensure it is accurately replicating actual traffic patterns. More information on model validation is provided in a separate report, but an important aspect that was discovered in compiling count data is the potentially implausible Interstate count volumes for the base year of 2022. Appendix C provides details on the issues discovered and the updates that were made to correct for this.

The model primarily includes major roadways, i.e. ones that are functionally classified as Collector and higher since those are the facilities for which performance is of utmost importance. In total there are just over 3,250 centerline miles of roadways included in the KRTM network for the entire 10-county study area. Figure 2 illustrates the model network in the dark black lines plus the Interstate system which is shown in blue. The "non-modeled" network is shown in the light gray lines. In general, greater network detail is provided within the core Knoxville TPO and Lakeway MTPO planning regions as compared with the other, more rural areas of the model study area.

Figure 2 - Travel Demand Model Roadway Network



EXISTING PLUS COMMITTED ROADWAY NETWORK

The primary purpose of the model is to forecast needs and deficiencies for the roadway network in the future assuming that population and economic activity continue to grow, but no improvement projects are undertaken beyond what is known as the "Existing plus Committed" or E+C network. The model roadway network was first updated to account for changes that have happened since the prior base year of 2018 to the new 2022 base year that was used in the validation process– this is known as the "Existing" network. The primary changes since 2018 resulted from roadway projects that were completed. Table 9 is a listing of major capacity-addition projects that were completed between 2018 and 2022.

Table 9 - Major Roadway Projects Completed between 2018 and 2022

Project Name	KRMP ID	Termini	Length (miles)	Project Description	Status
Alcoa Hwy (SR-115/US-129)	09-627	Maloney Rd to Woodson Dr	1.4	Widen 4-lane to 6-lane	Completed in 2022
Alcoa Hwy (SR-115/US-129)	09-208	Hall Rd (SR-35) to proposed interchange at Tyson Blvd	1.3	Widen from 4-lane divided to a 6-lane divided highway. Extend Tyson Boulevard under SR-115 and reconstruct Hunt Rd overpass	Completed in 2022
Chapman Hwy (US-441/SR-71)	09-626b	Evans Rd to Burnett Ln	0.9	Add center turn lane	Completed in 2021
Chapman Hwy (US-441/SR-71)	09-508	Boyds Creek Hwy (SR-338) to Macon Ln	1.2	Add center turn lane	Completed in 2022
Concord Rd (SR-332)	09-632	Turkey Creek Rd to Northshore Dr (SR-332)	0.8	Widen from 2 to 4/5 lanes	Completed in 2021
I-275 Industrial Park Access	09-618	W. Fifth Ave to Baxter Ave	0.5	Blackstock Ave: extend from Fifth Ave. to Bernard Ave.; Marion St: realign	Completed in 2022
I-640 at Broadway Interchange	09-611	I-640 at Broadway	0	Reconstruct and Relocate Ramps	Completed in 2021
Pellissippi Pkwy (SR-162/I-140) and Dutchtown Rd Interchange	09-623	I-40 to Dutchtown Rd Interchange	0.4	Widen Pellissippi Pkwy from 1 to 2 lanes westbound and lengthen storage of westbound off-ramp at Dutchtown Road interchange	Completed in 2021
Pellissippi Pkwy/Hardin Valley Interchange	09-634	Interchange at Hardin Valley Rd	0	Reconfigure existing interchange to improve safety and operations. Add new northbound on-ramp in NE quadrant	Completed in 2022
Robert C. Jackson Drive Extension	09-238	Lamar Alexander Pkwy (US-321/SR-73) to Morganton Rd	1.2	Construct new 2-lane roadway with sidewalks	Completed in 2021

Project Name	KRMP ID	Termini	Length (miles)	Project Description	Status
US 129 Widening	17-204	Mall Rd to Lamar Alexander Pkwy (US-321/SR-73)	0.7	Intersection improvements at W. Lamar Alexander Pkwy (US-321/SR-73) and addition of turn lanes	Completed in 2020
US 129 Widening	17-203	Foothills Mall Dr to Mall Rd	0.3	Intersection improvements at Foothills Mall Dr/Montgomery Ln and addition of turn lanes	Completed in 2022
US-321 (SR-73) Widening	09-423	E. Simpson Rd to north of SR-2 (US-11) in Lenoir City	1.4	Widen from 4 to 6 lanes	Completed in 2021
Western Ave (SR-62) Widening	09-610	Texas Ave to Major Ave	0.8	Widen from 2 to 5 lanes	Completed in 2020
US 411 Widening Jefferson County	N/A	SR-92 to Grapevine Hollow Rd	2.6	Widen 2-4 lane and new 4-lane	Completed 2022
SR-66 Relocated	N/A	North of I-81 to SR-160	5.7	Widen 2-4 lane and new 4-lane	Completed in 2020
Tesla Blvd	13-201	Associates Blvd to Hunt Rd (SR-335)	1.2	Construct new 4-lane	Completed in 2018
Marconi Blvd	13-206	Tesla Blvd to Springbrook Rd	0.8	Construct new 2-lane and 3-lane	Completed in 2022

In addition to the projects that were completed by 2022, other projects are considered to be “Committed” since it is reasonably certain that these will occur based on current expectations. The specific definition of a “Committed Project” for the purposes of Mobility Plan 2050 is that the project must either be currently under construction or is very likely to go to construction by July 2025 (when the new Mobility Plan takes effect). There is one minor exception to this rule that was made for two phases of Alcoa Highway (US-129/SR-115) which are not currently programmed for construction, but are assumed to be committed since all other segments of Alcoa Highway are either currently under construction or programmed for construction by FY 2026. The E+C projects form the baseline network with which subsequent roadway deficiency analyses and the Congestion Management Process analysis is undertaken with; however, it should be noted that this network does not necessarily represent the first air quality conformity horizon year (2026) since some projects such as a few Alcoa Highway segments are not projected to be open to traffic by that year given their large magnitude and length of time it will take for construction to be completed. Table 10 provides a listing of the Committed projects and their status (either under construction or funded for construction) as of May 2024:

Table 10 - Committed Project List

Project Name	KRMP ID	Termini	Length (miles)	Project Description	Status as of May 2024
Alcoa Hwy (SR-115/US-129) Widening	09-216	Pellissippi Pkwy (SR-162) to Little River (Knox/Blount C.L.)	3.2	Widen 4-lane to 6-lane with frontage road system and new interchange at Topside Rd (SR-333). Reconfigure existing interchange at Pellissippi Pkwy (SR-162) and signalize ramps	In ROW, No Construction Funds yet but Consider entire Alcoa Hwy corridor as committed at this point
Alcoa Hwy (SR-115/US-129) Widening	09-628	North of Little River (Knox/Blount C.L.) to Maloney Rd	2.4	Widen from 4 to 6 lanes including pedestrian and bicycle facilities.	Under Construction, Completion target of mid-2025
Alcoa Hwy (SR-115/US-129) Widening	09-653	Woodson Dr. to Cherokee Trail interchange	1.3	Widen 4-lane to 6-lane including pedestrian and bicycle facilities.	Under Construction, Completion target of late-2027
Relocated Alcoa Hwy (SR-115/US-129)	09-257 / 09-258	Proposed interchange at Tyson Blvd. to Pellissippi Pkwy (SR-162)	2.9	Construct new 4-lane divided highway with auxiliary lanes and new interchanges	Stage 1 Under Construction, Completion target of late-2027; Stage 2 construction start in 2028
Chapman Hwy (US-441/SR-71)	09-626d	Hendron Chapel Rd to Simpson Rd	0.9	Add center turn lane	Under Construction, Completion target of mid-2025
Foothills Mall Drive Extension to Foch Street	13-211	US-129 Bypass (SR-115) to Foch St.	0.5	Construct new 2-lane road with center turn lane and sidewalks	Construction Complete in 2023

Project Name	KRMP ID	Termini	Length (miles)	Project Description	Status as of May 2024
Schaad Rd Extension	09-605	Middlebrook Pk (SR-169) to W of Oak Ridge Hwy (SR-62)	4.6	Construct new 4-lane roadway with sidewalks	Under Construction, Completion target of late-2024
Pleasant Ridge Rd	09-616	Knoxville City Limits to Merchant Dr	1.6	Improve 2-lane with turn lanes at major intersections	Construction beginning late 2024
Maynardville Hwy (SR-33)	N/A – Union County	Knox County line to SR-144	5.3	Widen 2-lanes to 4-lanes	Under Construction, Completion target of Fall 2026
Jake Thomas Rd	N/A – Sevier County	Teaster Ln to Veterans Blvd (SR-449)	1.9	New 4-lane with Center Turn Lane	Construction Complete in 2024
US 411 Widening and Realignment	N/A – Jefferson & Sevier	SR-92 to Sims Rd	3.5	Widen 2-4 lane and new 4-lane	Under Construction, Completion target 2026
State Route 34 (US 11E)	N/A – Hamblen County	US 25E to E Morris Blvd	3.4	Two 12-foot travel lanes in each direction and Continuous center turn lane	Construction beginning late 2024

Appendix A: Employment Data Development

The TPO staff undertook a comprehensive review of available employment data sources in order to develop the base year 2022 Countywide and TAZ-level estimates of place of work employment by the four major categories of: Basic, Industrial, Service and Retail. This Appendix describes first the process to arrive at a County-level control total of employment by major category and secondly, the allocation of employees at the TAZ-level.

COUNTY-LEVEL CONTROL TOTAL DEVELOPMENT

As noted in the main section of this document, there is no official "census" of employment as there is with population but there are various governmental and proprietary data sources available with which to derive estimates. It is important to note that in the context of the travel demand model, employment is specifically at the place of work, i.e. not the number of workers at the residence location. In other words, the model uses number of jobs, and accounts for the fact that persons can have more than one job.

The two primary governmental sources for counts of workers available at the county scale are the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS). The TPO purchased socioeconomic projection data from Woods & Poole Economics, inc (W&P) as noted earlier in this document and it bases employment estimates on the BEA data source. It provides estimates of employment at the 2-digit summation level of the North American Industry Classification System (NAICS). The W&P technical documentation states the following (emphasis added):

> The employment data in the Woods & Poole database are a complete measure of the number of full- and part-time jobs by place of work. Historical data, 1969-2021, are from the U.S. Department of Commerce, Bureau of Economic Analysis, released in November 2022. The employment data include wage and salary workers, proprietors, private household employees, and miscellaneous workers. Wage and salary employment data are based on an establishment survey in which employers are asked the number of full- and part-time workers at a given establishment. Because part-time workers are included, a person holding two part-time jobs would be counted twice. Also, since the wage and salary employment data are based on an establishment survey, jobs are counted by place of work and not place of residence of the worker. **The employment data used by Woods & Poole comprise the most complete definition of the number of jobs by county. Woods & Poole data may be higher than that from other sources because they measure more kinds of employment.**

In contrast, the BLS data show much fewer jobs than BEA mainly due to the fact that some job categories are omitted from BLS such as agricultural workers, the military, proprietors, households and miscellaneous employment The exclusion of sole proprietorships appears to be the most significant difference according to the W&P documentation. At the same time, based on TPO staff experience, the BEA estimate of total jobs seems to be too high and likely due to an overcounting of sole proprietorship employees. It is not certain as to the specific reasons for the overcounting although it may be likely that some self-employed individuals establish multiple "doing business as" names that each get counted but do not function as separate employers.

At the 10-County KRTM level there is a significant difference between the employment estimates from W&P (BEA) and BLS as shown below:

	Year 2022 Total Employment		
	W&P(BEA)	**BLS**	**Difference**
10-County KRTM Region	**666,585**	**496,274**	**170,311**

Guidance provided by the TPO's travel demand model development consultant; Vince Bernardin with Caliper Corporation, was obtained to develop a modified total employment estimate to reconcile between the two sources. The table on the following page shows the rationale for development of an in-between estimate to be used as county-level control totals from the W&P data.

10-County Knoxville TPO Travel Demand Model Area

2022 Employment Total Comparison between Woods&Poole (BEA) and BLS

2-Digit NAICS	Employment Category Description	Year 2022 Total Employment W&P(BEA)	BLS	Final Estimate	Source	Rationale
N/A	Farm Employment (BEA only)	7,515		7,515	BEA	only one estimate available
11	FORESTRY, FISHING, RELATED ACTIVITIES	1,124	1,048	1,124	BEA	reasonable proprietorships
21	MINING	1,108	436	772	average	BEA too high
22	UTILITIES	454	3,196	3,196	BLS	Keep public utilities employees under utilities
23	CONSTRUCTION	38,738	24,701	38,738	BEA	expected to have significant proprietorships
31	MANUFACTURING	56,759	59,588	58,174	average	unknown reason for difference between BEA & BLS
42	WHOLESALE TRADE	20,157	18,453	19,305	average	proprietorships expected to be low
44	RETAIL TRADE	73,450	62,867	73,450	BEA	reasonable proprietorships
48	TRANSPORTATION and WAREHOUSING	25,412	20,267	25,412	BEA	reasonable proprietorships
51	INFORMATION	7,661	6,356	7,661	BEA	reasonable proprietorships
52	FINANCE and INSURANCE	29,153	14,395	21,774	average	BEA too high
53	REAL ESTATE and RENTAL and LEASE	31,321	7,056	10,584	1.5*BLS	known issue with BEA estimates
54	PROFESSIONAL and TECHNICAL SERVICES	45,179	29,958	37,569	average	proprietorships expected to be lower than BEA
55	MANAGEMENT of COMPANIES and ENTERPRISES	9,937	8,276	9,107	average	proprietorships expected to be lower than BEA
56	ADMINISTRATIVE and WASTE SERVICES	51,531	34,256	42,894	average	proprietorships expected to be lower than BEA
61	EDUCATIONAL SERVICES	10,820	36,242	36,242	BLS	keep public educators under education
62	HEALTH CARE and SOCIAL ASSISTANCE	66,780	59,493	66,780	BEA	reasonable proprietorships, non-profits
71	ARTS, ENTERTAINMENT, and RECREATION	17,842	10,625	14,234	average	BEA too high
72	ACCOMMODATION and FOOD SERVICES	65,496	60,435	65,496	BEA	reasonable proprietorships
81	OTHER SERVICES, EXCEPT PUBLIC ADMINISTRATION	36,865	13,216	19,824	1.5*BLS	BEA seems very high
92	GOVERNMENT	69,283	17,895	41,119	BEA	Subtracted Utilities and Educators
	TOTAL	**666,585**	**496,274**	**600,968**		

Summary by 4 Major Categories used by KRTM

Category	W&P(BEA)	BLS	Final Estimate	
Basic	48,939	29,381	51,345	higher because of public utilities and proprietorships
Industrial	102,328	98,308	102,891	essentially same as BEA
Retail	138,946	123,302	138,946	BEA
Service	376,372	237,768	307,786	essentially split the difference between BEA and BLS
TOTAL	**666,585**	**496,274**	**600,968**	

TAZ-LEVEL EMPLOYMENT ALLOCATION

The primary data source used to allocate employment by each of the four major categories to the KRTM Traffic Analysis Zones (TAZ) is the proprietary establishment-level data acquired by the Tennessee Department of Transportation known as InfoGroup data, which has recently rebranded as “Data Axle”. The InfoGroup data is a comprehensive business database that contains several data attributes and most importantly an estimate of the number of employees at each business location which has been geocoded to its actual location where possible.

Since it is a national data provider it is important to perform quality control checks on the database and compare it against other data sources and local knowledge. The TPO staff spent significant time in reviewing the data and made several adjustments to improve its accuracy and completeness. The main quality control (QC) process involved reviewing the locations of highest employment such as hospitals, universities and major industries to ensure the proper employment category, number of employees and locations were accurate when comparing against other available data sources. An important data field in the InfoGroup database is the “match level code” which indicates the quality of its geocoding. The geocoding quality can range from exact match to the centroid of the zip code where it is located. Since the TAZs are a relatively small geographic unit it is extremely important to ensure that major employers are geocoded as closely as possible to their actual location.

After completion of the QC process the InfoGroup data was aggregated by employment category to each TAZ and the county totals were compared against the control totals discussed in the previous section of this Appendix. It was noted that the aggregation of the InfoGroup data at the county level compared very well with the “modified” control total as opposed to the original W&P (BEA) estimates which seems to further confirm that the BEA numbers are probably overstated. As a final step, the TAZ employment was factored up proportionally in order to exactly match the county-level control total. In most cases the only factoring needed was for the “Basic” employment category, which is to be expected due to the transient nature of some of these employees such as in the construction trades.

The tables on the following page show the original BEA county-level employment compared against the “modified” employment control totals and the aggregated InfoGroup totals for the four primary counties included in the TPO Planning Area of: Anderson, Blount, Knox and Loudon:

Anderson County	Original Woods & Poole (BEA)	Modified Employment Control Total	InfoGroup
Basic	3,068	3,358	2,802
Industrial	14,628	15,639	15,639
Retail	7,914	7,914	7,914
Service	27,126	22,839	22,839
Total	**52,736**	**49,750**	**49,194**

Blount County	Original Woods & Poole (BEA)	Modified Employment Control Total	InfoGroup
Basic	6,357	6,333	4,487
Industrial	13,919	13,980	13,980
Retail	14,415	14,415	14,415
Service	40,256	31,745	31,745
Total	**74,947**	**66,473**	**64,627**

Knox County	Original Woods & Poole (BEA)	Modified Employment Control Total	InfoGroup
Basic	21,370	22,676	19,848
Industrial	41,997	41,671	41,671
Retail	65,660	65,660	65,660
Service	211,418	176,225	176,225
Total	**340,445**	**306,232**	**303,404**

Loudon County	Original Woods & Poole (BEA)	Modified Employment Control Total	InfoGroup
Basic	2,979	3,262	1,766
Industrial	5,764	5,704	5,689
Retail	5,133	5,133	4,539
Service	11,863	8,456	8,312
Total	**25,739**	**22,555**	**20,306**

Appendix B: Master Network Attribute Fields

Field	Description	Codes/Units:	Files:	Maintained by:	Used for:
ID	TransCAD ID		Input & Output	TransCAD	Various
Length	Length	miles	Input & Output	TransCAD	Various
Dir	Directionality	0: two-way 1: one-way (A to B) -1: one-way (B to A)	Input & Output	TransCAD	Various
BusTime	Bus Travel Time	Minutes	Input & Output	User	Tour Mode Choice
STCO	State County Number		Input & Output		Post_Alt
FC_HPMS	Functional Classification			User	Reference
County	County Name			User	Reference
Lampto	Lakeway MTPO network link			User	Reference
PM25_Flag	Link within the PM2.5 Maintenance Area	0: not in 1: in		User	Reference
O3_Flag	Link within the Ozone Maintenance Area	0: not in 1: in		User	Reference
AreaType_FC	Urban or Rural indicator per the FC code			User	Reference
Cnt_Sta	Count Station ID		Input & Output	User	Reference
[2023_ADT]	2023 ADT		Input & Output	User	Reference
[2022_ADT]	2022 ADT		Input & Output	User	Reference

Field	Description	Codes/Units:	Files:	Maintained by:	Used for:
[2022_ADT_Corr]	2022 ADT corrected for potential Interstate volume errors		Input & Output	User	Reference
[2021 ADT]	2021 ADT		Input & Output	User	Reference
ADT_Model	ADT for validation		Input & Output	User	Cal_Rep
CO_NUM	County Number		Input & Output	User	
Corridor	User-defined Corridors		Input & Output	User	Post_Alt
AltVDF	Special Volume Delay Function	1, 3, 5, 6, 7: a = 2.0 b = 4.5 4: a = 0.2 b = 10.0	Input & Output	Developer	Speed-capacity
WaterWayXing	Major Waterway Crossing	1: Yes	Input & Output	User	Stop Location Choice
CountyXing	County Line Crossing	1: Yes	Input & Output	User	Stop Location Choice
Net(_#)	Flag field to indicate link is part of network scenario #	Active if = scenario # Inactive if <> #	Input & Output	User	GUI
FHWA_FC(_#)	Federal functional class	1: Rural Interstate 2: Rural Principal Arterial 6: Rural Minor Arterial 7: Rural Major Collector 8: Rural Minor Collector 9: Rural Local 11: Urban Interstate	Input & Output	User	Speed-capacity (only approach priority), Post_Alt, Cal_Rep

Field	Description	Codes/Units:	Files:	Maintained by:	Used for:
		14: Urban Principal Arterial 16: Urban Minor Arterial 17: Urban Collector 19: Urban Local 71: Off Ramp 72: On Ramp 73: Ramp (Major to Major Fwy) 74: Ramp (Minor to Major Fwy) 75: Generic Ramp 81: Median cross-over 99: Centroid Connector			
HOV(_#)	Flag field for HOV facilities	Greater than 0 indicates HOV only	Input & Output	User	Assignment
Divided(_#)	Flag field to indicated divided facilities	0: Undivided 1: Divided	Input & Output	User	Speed-capacity
Access(_#)	Access Control Level	1: None 2: Partial 3: Full	Input & Output	User	Speed-capacity
Lanes(_#)	Number of Lanes (not counting auxiliaries)		Input & Output	User	Speed-capacity
LN1DIR(_#)	Lanes in One Direction		Input & Output	User	Speed-capacity

Field	Description	Codes/Units:	Files:	Maintained by:	Used for:
AuxLanes(_#)	Number of Auxiliary Lanes		Input & Output	User	Speed-capacity
AB_Lane(_#)	Lanes in the AB direction		Input & Output	User	Speed-capacity
BA_Lane(_#)	Lanes in the BA direction		Input & Output	User	Speed-capacity
LN_Width(_#)	Lane width (feet)		Input & Output	User	Speed-capacity
RS_Width(_#)	Right shoulder width	Feet	Input & Output	User	Speed-capacity
Posted_Speed(_#)	Posted speed	Miles per hour	Input & Output	User	Speed-capacity
A_Signal	A node control	null: no control 1: signal 2: 2-way stop 3: all-way stop	Output	Speed-capacity	Reference
B_Signal	B node control	null: no control 1: signal 2: 2-way stop 3: all-way stop	Output	Speed-capacity	Reference
A_Priority	A node approach priority	1: High priority 2: Equal priority 3: Low priority	Output	Speed-capacity	Reference
B_Priority	B node approach priority	1: High priority 2: Equal priority 3: Low priority	Output	Speed-capacity	Reference
A_upSigs	Number of signals upstream from A		Output	Speed-capacity	Reference

Field	Description	Codes/Units:	Files:	Maintained by:	Used for:
B_upSigs	Number of signals upstream from B		Output	Speed-capacity	Reference
CanWalk	Pedestrian travel possible	0: No 1: Yes	Input	User	Walk Access to Transit

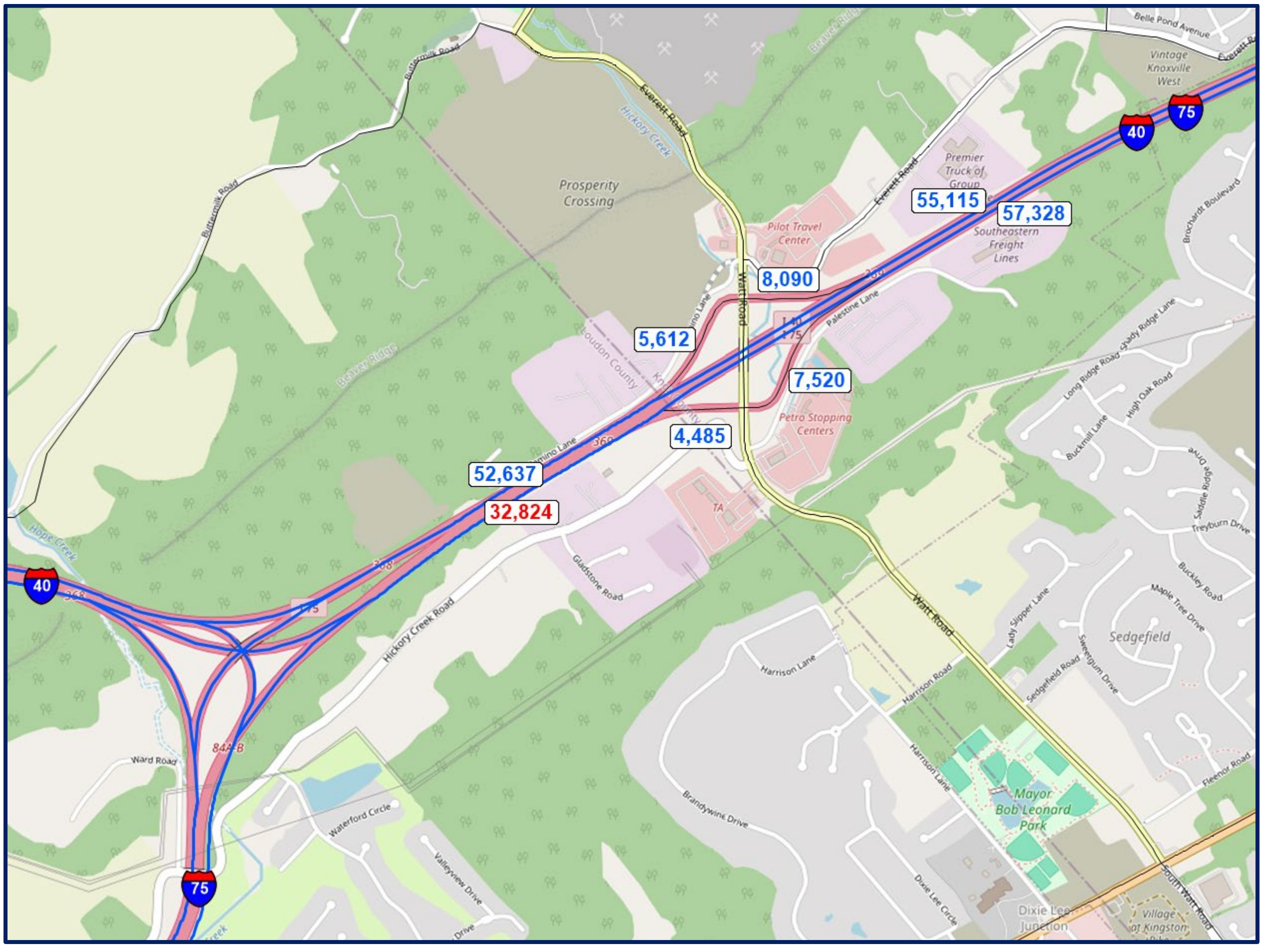
Appendix C: Interstate Count Modifications

As discussed in the main section of this report, actual traffic counts collected on the region's roadways are an important data source that is used to validate that the travel demand model is accurately replicating traffic volumes. A separate "Model Validation Report" is available that documents how well the updated 2022 base year KRTM is matching traffic volumes. The purpose of this appendix is to document changes that were made in order to correct potential errors that were observed in the year 2022 traffic count data.

The corrections were all for Interstate roadways in the Knoxville Region which present unique challenges for count data collection due to their high volumes and speeds. The normal process for collecting traffic count volumes is to place a pneumatic tube across the roadway which is hooked into a small device that can sense and tabulate each pulse of air that is created as a vehicle passes over it. This methodology is not feasible for a multilane high-speed facility such as an Interstate due to both safety concerns during its installation as well as being able to keep the tubes in place for the needed duration of time. Instead of using these types of counters on the mainline Interstate, TDOT instead counts the on and off ramps in between certain "control" points on the mainline where permanent inductive loops have been installed and estimates the volumes in between in a process known as "ramp-balancing". This process can be challenging due to several factors including variability in traffic patterns when ramps are counted that affect how well the real volume can be estimated as well as if control point volumes are in error.

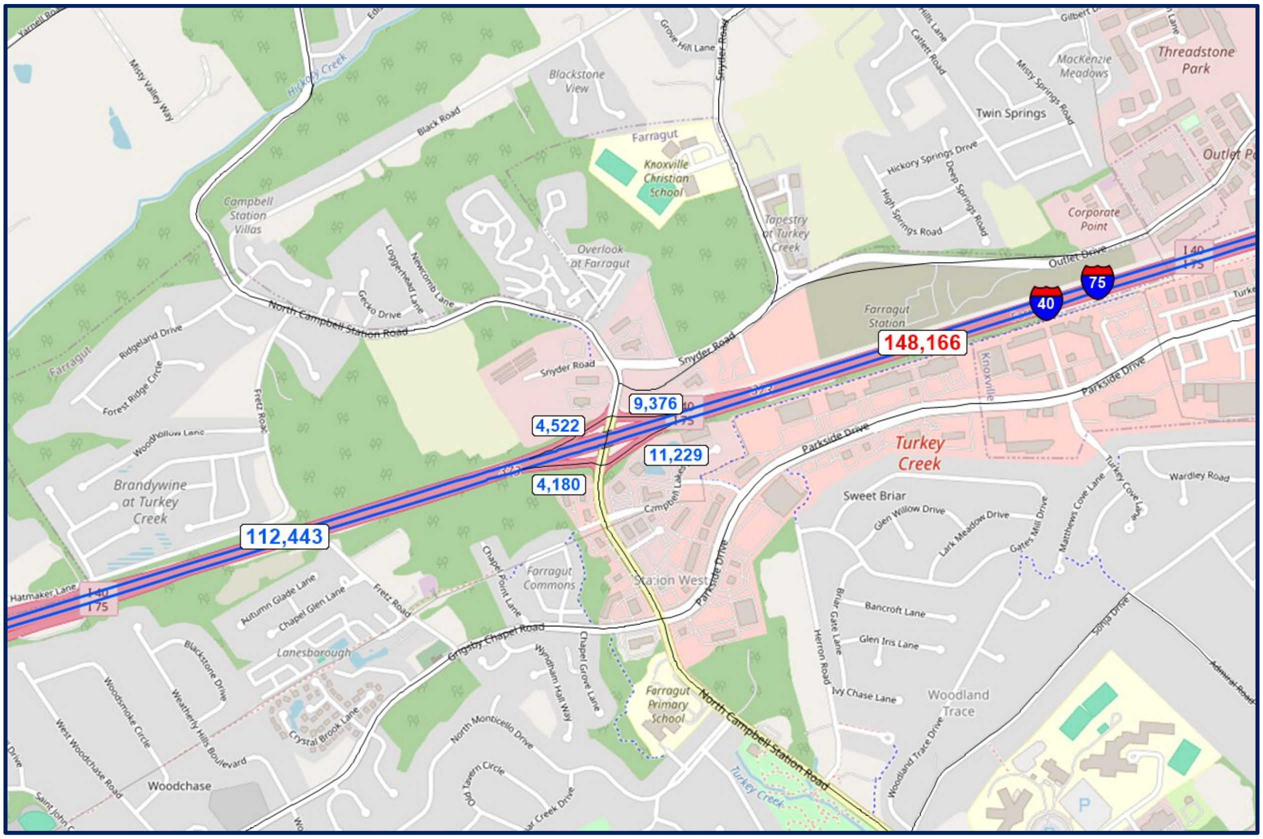
The primary error that was discovered was on the highest volume sections of Interstate in the Knoxville Region which are along the combined segments of I-40 and I-75 through west Knox County, which have the highest average daily traffic in the entire State of Tennessee at greater than 200,000 vehicles per day. In particular, there were obvious discrepancies at the extreme western end of I-40/75 between the junction of the two interstates and the next two interchanges to the east which are Watt Road and Campbell Station Road. Figure C-1 shows the discrepancy east and west of the Watt Road interchange and Figure C-2 shows the discrepancy east and west of the Campbell Station Road interchange. These errors essentially propagated through the rest of the network and had to be corrected for the segments going southward towards Loudon County and eastward towards downtown Knoxville. Other similar errors were corrected for where observed on sections of I-640, I-275, I-140.

Figure C-1 – Count Discrepancy at I-40/75 & Watt Road Interchange



In the figure above, it is obvious that the eastbound volume shown in red text of 32,824 is an anomaly when compared with the other mainline and ramp volumes shown. If one assumes that the eastbound volume of 57,328 shown east of the Watt Road Interchange is accurate (it is coming from a permanent TDOT count station as well) then after adding and subtracting the ramp volumes in the eastbound direction the actual count should instead be 54,293, calculated as follows: 57,328 – 7,520 + 4,485 = 54,293.

Figure C-2 – Count Discrepancy at I-40/75 & Campbell Station Road Interchange



The figure above shows the apparent discrepancy in total Interstate volume east and west of the Campbell Station Road Interchange. Again, if we assume that the count on the west side is accurate since it is coming from a permanent count station then it would be impossible to obtain the volume shown in red text of 148,166 vehicles per day based on the ramp volumes. The total volume at this location should instead be 124,346, calculated as follows: 112,443 - (4,522+4,180) + (11,229+9,376) = 124,346.

The TPO staff made some other minor adjustments in the final calculations such as modifying a few individual ramp volumes that seemed to be outliers compared with historical years or to correct for directional imbalances. Tables are provided on the following page that show the before and after volumes for the base year 2022 and compared against other historical count years. It can be seen that overall the corrected values tend to align with historical patterns and averages, which increases the confidence in their use.

I-75 South	Station ID	2019 ADT	2021 ADT	2022 ADT	2023 ADT	AVG	Corrected ADT
External Station - Pond Creek Rd	62000079	44,367	45,154	43,194	49,167	45,471	43,194
Pond Creek Rd - SR 72	53000069	45,826	46,084	44,443	50,662	46,754	44,443
SR 72 - Sugar Limb Rd	53000070	54,064	52,785	56,682	57,638	55,292	52,424
Sugar Limb Rd - US 321	53000071	56,236	55,134	53,454	54,683	54,877	54,324
US 321 - I-40 Junction	53000050	60,473	58,302	55,469	53,771	57,004	63,090

I-40/75	Station ID	2019 ADT	2021 ADT	2022 ADT	2023 ADT	AVG	Corrected ADT
I-40/75 Junction - Watt Rd	53000121	104,518	100,765	85,461	86,756	94,375	106,930
Watt Rd - CSR	ATR 37	109,381	79,585	112,443	112,023	103,358	112,443
CSR - Lovell Rd	47000165	125,373	93,462	148,166	132,443	124,861	126,492
Lovell Rd - I-140	47000254	142,671	114,045	163,925	147,689	142,083	142,251
I-140 - Cedar Bluff	47000164	195,109	154,869	196,701	170,970	179,412	179,242
Cedar Bluff - WS	47000253	206,559	166,251	207,271	191,951	193,008	189,812
WS - West Hills	47000252	206,396	173,049	214,055	194,969	197,117	196,596
West Hills - Papermill	47000124	211,494	179,856	218,583	201,281	202,804	201,124
Papermill Rd - I-640 West	47000170	215,216	182,502	211,587	204,861	203,542	203,770

I-640	Station ID	2019 ADT	2021 ADT	2022 ADT	2023 ADT	AVG	Corrected ADT
I-40 W - Western Ave	47000274	97,540	90,947	95,838	77,248	90,393	94,099
Western Ave - I-75	47000330	96,724	94,386	104,064	74,534	92,427	95,818
I-75 - Broadway	47000251	97,988	89,826	98,829	73,997	90,160	88,065
Broadway - Millertown Pk	47000331	79,741	71,684	76,691	52,840	70,239	65,927
Millertown Pk - I-40 E	47000332	74,397	69,368	70,244	47,561	65,393	59,480

I-275	Station ID	2019 ADT	2021 ADT	2022 ADT	2023 ADT	AVG	Corrected ADT
I-40 - Baxter Ave	47000256	72,488	67,587	61,084	64,319	66,370	77,228
Baxter Ave - Woodland Ave	47000249	71,386	64,366	59,409	62,518	64,420	75,553
Woodland Ave - Heiskell Ave	47000166	68,660	60,703	55,417	59,164	60,986	71,561
Heiskell Ave - I-640	47000250	67,702	63,125	54,478	59,832	61,284	70,622

I-140	Station ID	2019 ADT	2021 ADT	2022 ADT	2023 ADT	AVG	Corrected ADT
Cusick Rd - US 129	05000191	18,521	18,849	16,303	20,036	18,427	17,236
US 129 - Topside Rd	05000183	42,872	37,064	39,490	41,429	40,214	39,490
Topside Rd - Northshore Dr	05000184	49,414	43,920	47,687	50,430	47,863	47,687
Northshore Dr - Westland Dr	47000414	48,609	47,990	47,462	54,620	49,670	49,819
Westland Dr - Kingston Pk	47000415	55,861	54,523	55,194	65,616	57,799	57,262
Kingston Pk - I-40	47000419	64,579	60,213	65,390	74,676	66,215	67,458

The TPO staff essentially conducted its own "ramp balancing" process in order to obtain the corrected base year 2022 volumes shown in the table above. An example of how this was conducted is shown below for I-640 where directional volumes were used and ramp volumes were added and subtracted. The volumes on the right side of the table were plugged in to the columns on the left side to replace the original volumes where discrepancies were found.

			EB	ORIGINAL ADT	WB		checksum	EB	NEW ADT	WB
I-40 East		6,176				6,814				
		21,507				24,983				
			27,683	**70,244**	31,797		59,480	27,683	**59,480**	31,797
Mall		8,355				9,000				
		12,664				11,138				
			31,992	**76,691**	33,935		65,927	31,992	**65,927**	33,935
Broadway		6,530				6,986				
		17,779				17,875				
			43,241	**98,829**	44,824		88,065	43,241	**88,065**	44,824
Sharp Gap		22,361				23,901				
		26,891				27,124				
			47,771	**104,064**	48,047		95,818	47,771	**95,818**	48,047
Western Ave		10,527				11,300				
		9,791				10,317				
			47,035	**95,838**	47,064		94,099	47,035	**94,099**	47,064
I-40 West		44,704				45,978				
		7,438				5,314				

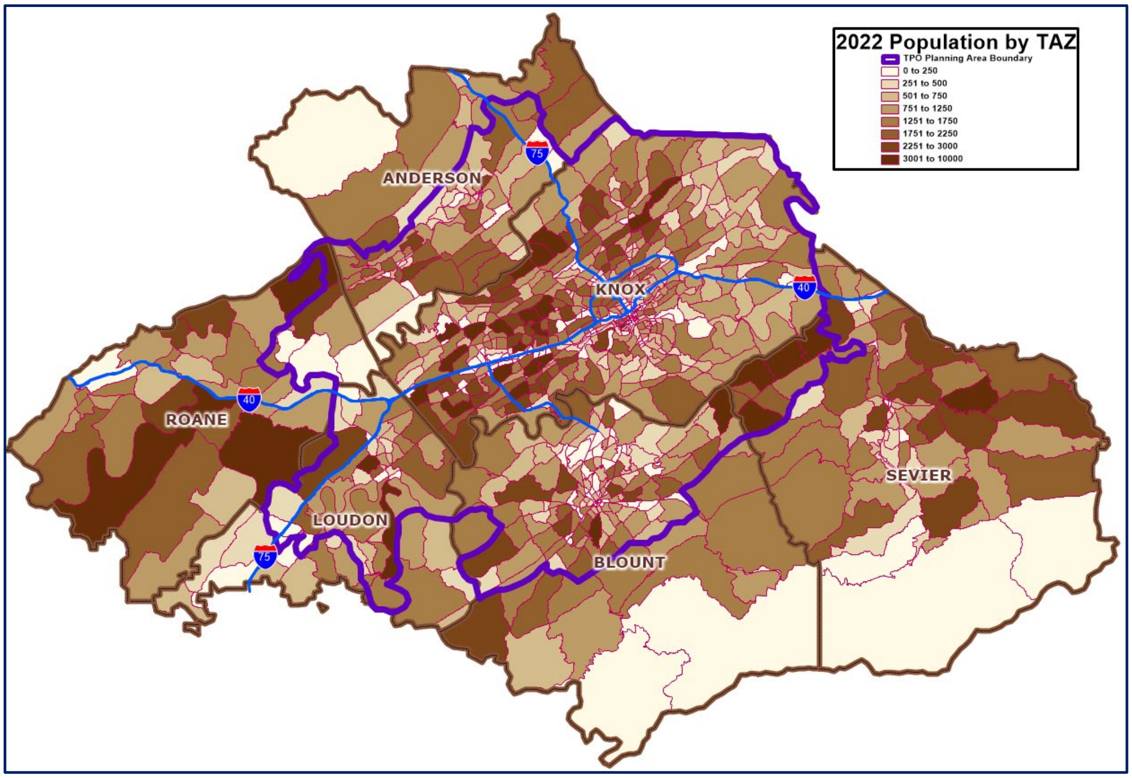
Appendix D: External Station Traffic Volume Forecast

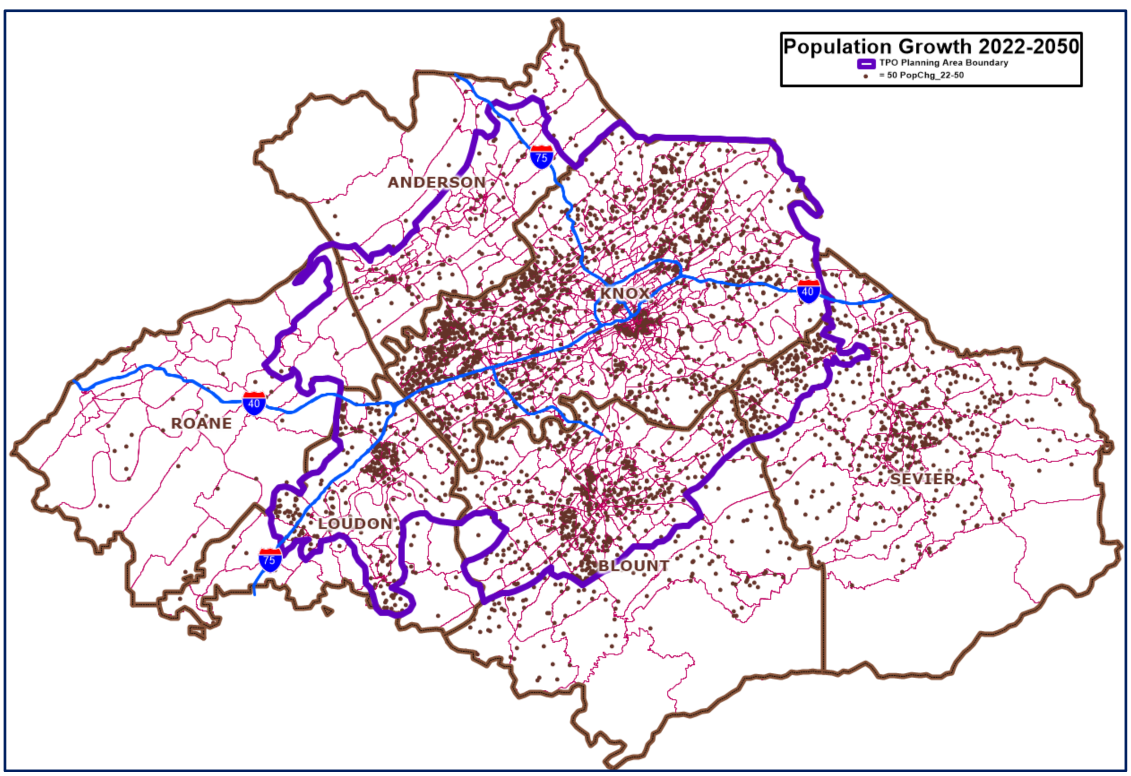
The External Station traffic growth methodology used was to extrapolate historical traffic count data from various timeframes and utilize judgement to select a reasonable growth rate. The primary methodology was to use the linear trend extrapolation in Excel utilizing 2010 - 2023 actual count data and going out to the year 2050. Other considerations were reviewing the linear trend starting back in 1995 and comparing with the TDOT Statewide Model volume predictions at these locations available for 2045.

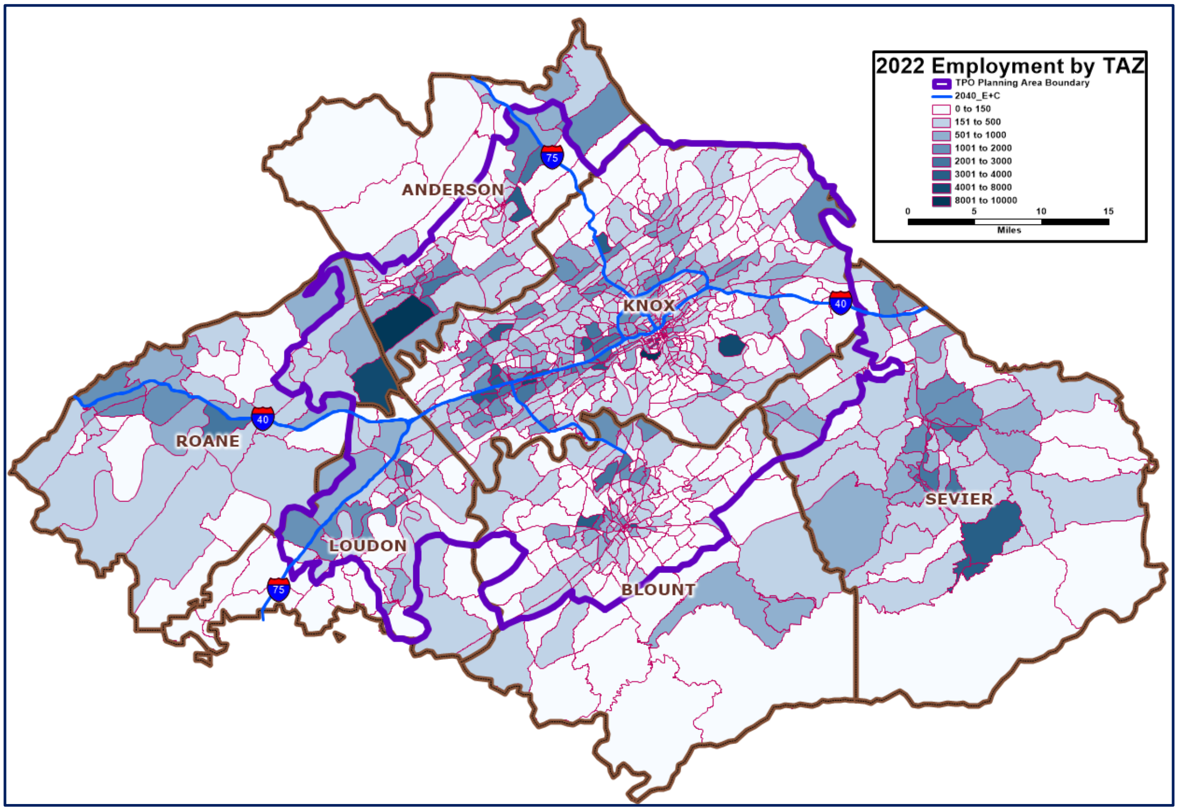
Some of the lower volume stations exhibited very low or even negative growth which was deemed to be unreasonable so a minimum factor of 1.14 times the base year 2022 volume was used which represents a linear rate of 0.5% per year over the 28-year time period between 2022 - 2050.

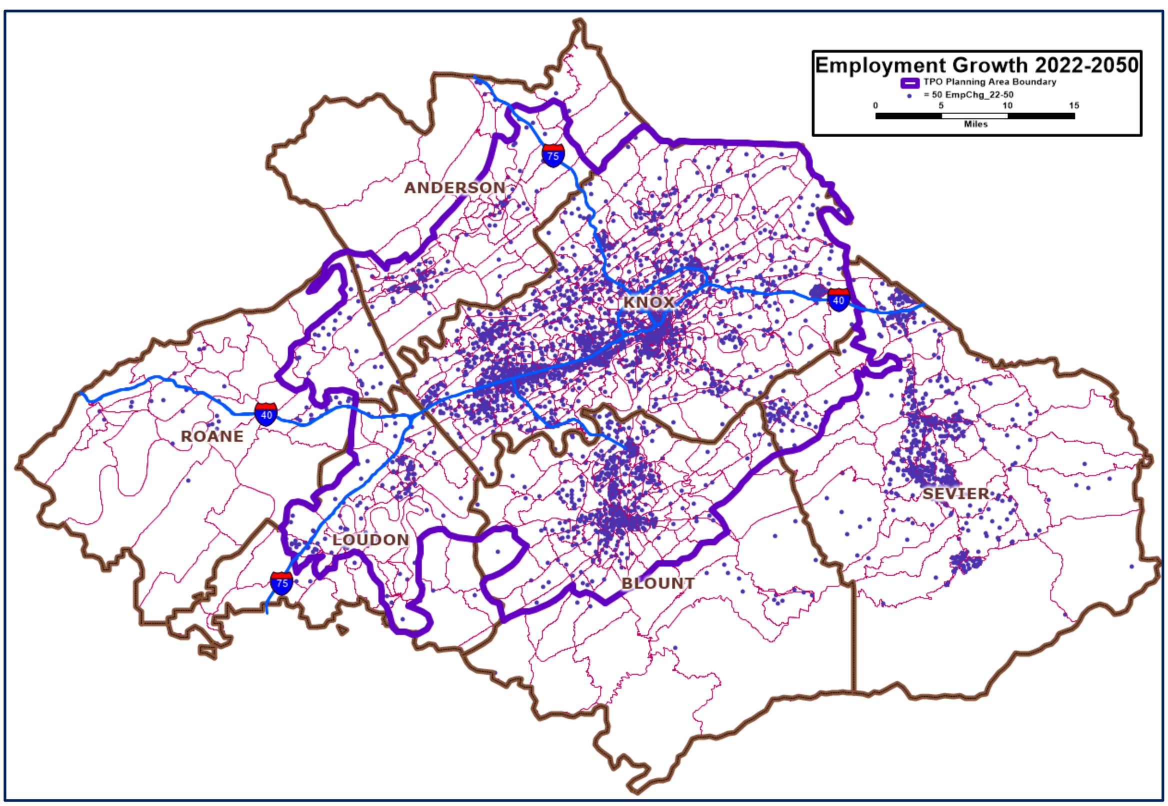
TAZID	Count Station	COUNTY	Route	LOCATION	Actual AADT_2022	Forecasted 2026	Forecasted 2035	Forecasted 2040	Forecasted 2050
9001	73000158	Roane	I0040	NEAR CUMBERLAND CO LINE	32,292	34,278	38,745	41,227	46,191
9002	73000007	Roane	SR029	NEAR MORGAN CO LINE	3,788	4,033	4,583	4,889	5,500
9003	65000038	Morgan	SR062	NEAR ANDERSON CO. LINE	9,604	10,386	12,145	13,122	15,077
9004	07000094	Campbell	I0075	(LOOPS) NEAR ANDERSON CO LINE	45,938	46,966	49,279	50,565	53,135
9005	07000075	Campbell	SR116	NEAR ANDERSON CO LINE	3,378	3,446	3,598	3,682	3,851
9006	87000005	Union	SR033	SR033 NORTH OF MAYNARDVILLE	8,430	9,073	10,519	11,322	12,929
9007	29000008	Grainger	SR032	SR032 N. OF THORN HILL	9,776	10,230	11,252	11,819	12,954
9008	29000001	Grainger	SR131	NEAR HANCOCK CO LINE	700	749	858	919	1,041
9009	29000053	Grainger	SR001	NEAR HAWKINS CO LINE	10,700	11,670	13,852	15,064	17,488
9010	32000001	Hamblen	02528	EAST OF NEEDMORE	254	259	271	277	290
9011	37000076	Hawkins	SR113	S.W. OF ST. CLAIR	3,028	3,089	3,225	3,301	3,452
9012	37000123	Hawkins	SR034	SR034 NEAR HAMBLEN CO. LINE	5,866	5,983	6,247	6,394	6,687
9013	32000080	Hamblen	02469	BEACON D - NEAR GREENE CO LINE	382	390	407	416	435
9014	30000120	Greene	I0081	[LOOPS] NEAR HAMBLEN CO LINE	39,896	42,401	48,039	51,170	57,434
9015	32000036	Hamblen	SR340	NEAR GREENE CO LINE	1,788	1,824	1,904	1,949	2,038
9016	15000001	Cocke	SR160	NEAR HAMBLEN CO LINE	2,128	2,171	2,266	2,320	2,426
9017	32000039	Hamblen	02461	W. MORRISTOWN	748	798	909	971	1,095
9018	15000019	Cocke	SR032	NW OF NEWPORT	7,352	7,499	7,830	8,014	8,381
9019	15000129	Cocke	I0040	[LOOPS] BETWEEN JEFFERSON CO LINE & SR-9	30,962	33,103	37,922	40,598	45,952
9020	15000020	Cocke	SR009	NEAR JEFFERSON CO LINE	5,376	5,484	5,726	5,860	6,129
9021	15000131	Cocke	05966	NEAR JEFFERSON CO LINE	14,050	14,692	16,137	16,939	18,544
9022	15000051	Cocke	SR339	NW OF COSBY	2,698	2,908	3,381	3,644	4,170
9023	15000057	Cocke	SR073	S OF COSBY	5,088	5,330	5,874	6,176	6,781
9024	78000068	Sevier	SR071	S. OF GATLINBURG	5,956	6,075	6,343	6,492	6,790
9025	05000088	Blount	SR115	NEAR MONROE COUNTY LINE	1,442	1,550	1,794	1,930	2,201
9026	16	Blount	SR115	NEAR MONROE COUNTY LINE	15,326	15,757	16,725	17,264	18,340
9027	62000106	Monroe	SR072	SR072 NORTHEAST OF MADISONVILLE	14,410	15,245	17,124	18,168	20,255
9028	62000001	Monroe	SR002	NEAR LOUDON CO LINE	3,628	3,701	3,864	3,955	4,136
9029	62000079	Monroe	I0075	NORTHWEST OF SWEETWATER	43,194	45,278	49,967	52,571	57,781
9030	53000086	Loudon	SR322	NEAR MONROE CO LINE	1,636	1,672	1,753	1,799	1,889
9031	73000032	Meigs	SR058	NEAR ROANE CO LINE	3,006	3,116	3,362	3,499	3,773
9032	72000046	Rhea	SR029	NEAR ROANE CO LINE	4,952	5,051	5,274	5,398	5,645
9033	18000029	Cumberland	SR001	NEAR ROANE CO. LINE	1,918	2,034	2,296	2,442	2,733

Appendix E: Knoxville TPO Area Future-Year Population and Employment Growth by TAZ

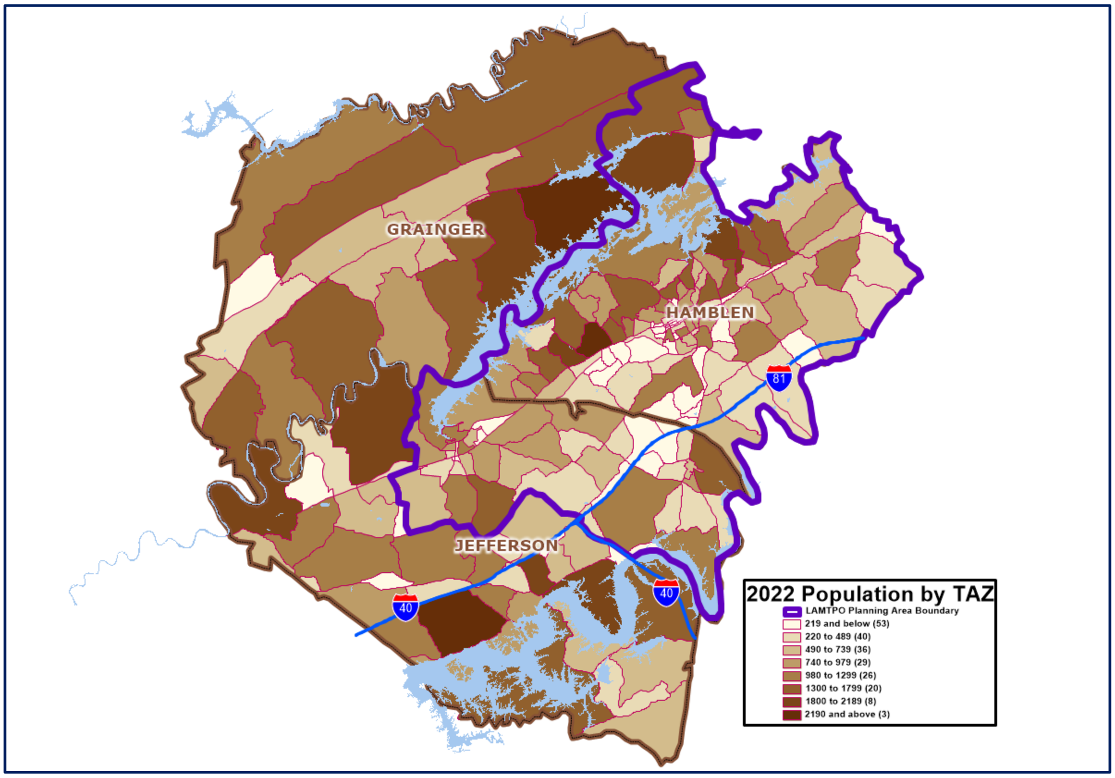


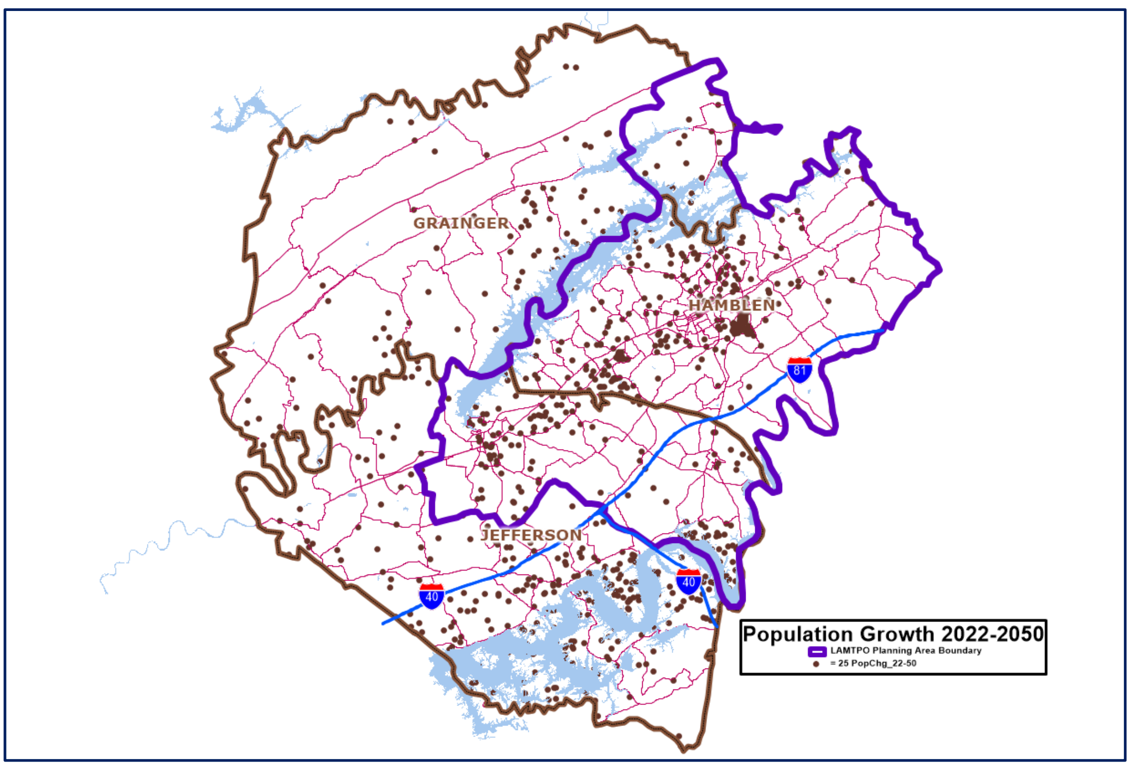


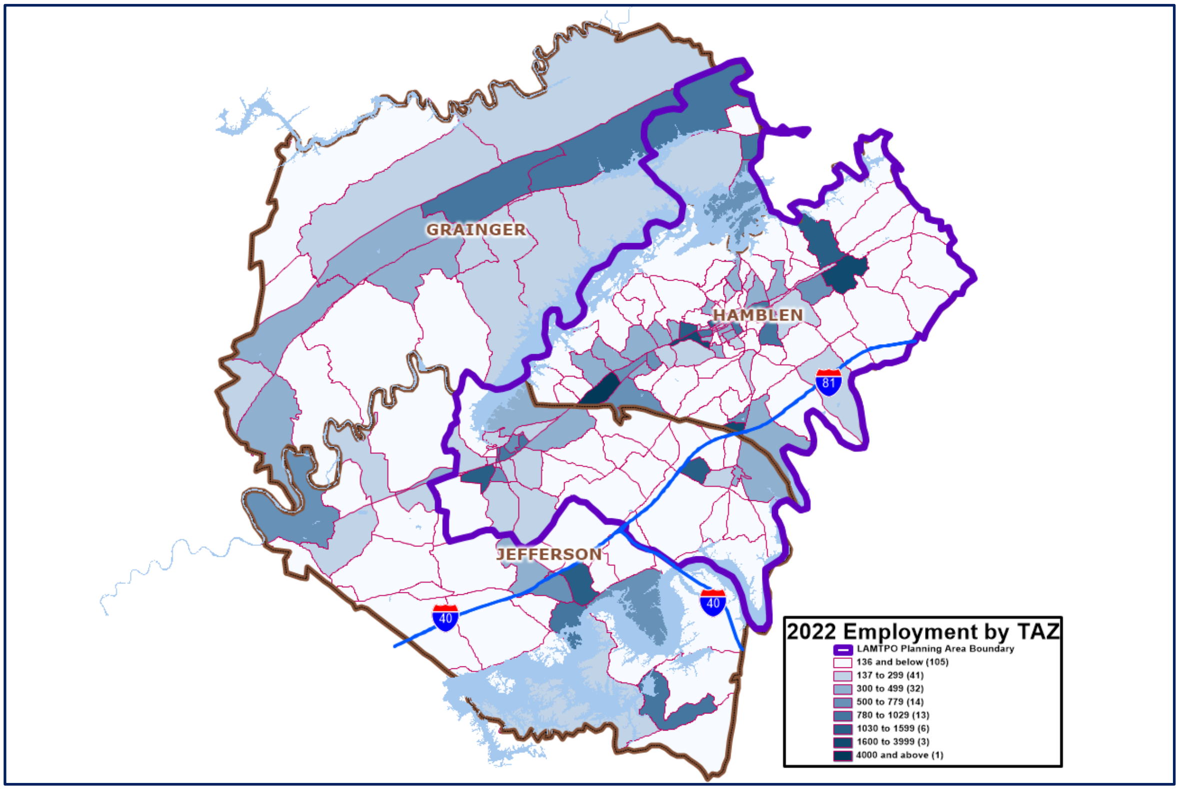

2022 Employment by TAZ
TPO Planning Area Boundary
2040_E+C
0 to 150
151 to 500
501 to 1000
1001 to 2000
2001 to 3000
3001 to 4000
4001 to 8000
8001 to 10000
0
5
10
15
Miles
ANDERSON
KNOX
ROANE
LOUDON
BLOUNT
SEVIER
75
40

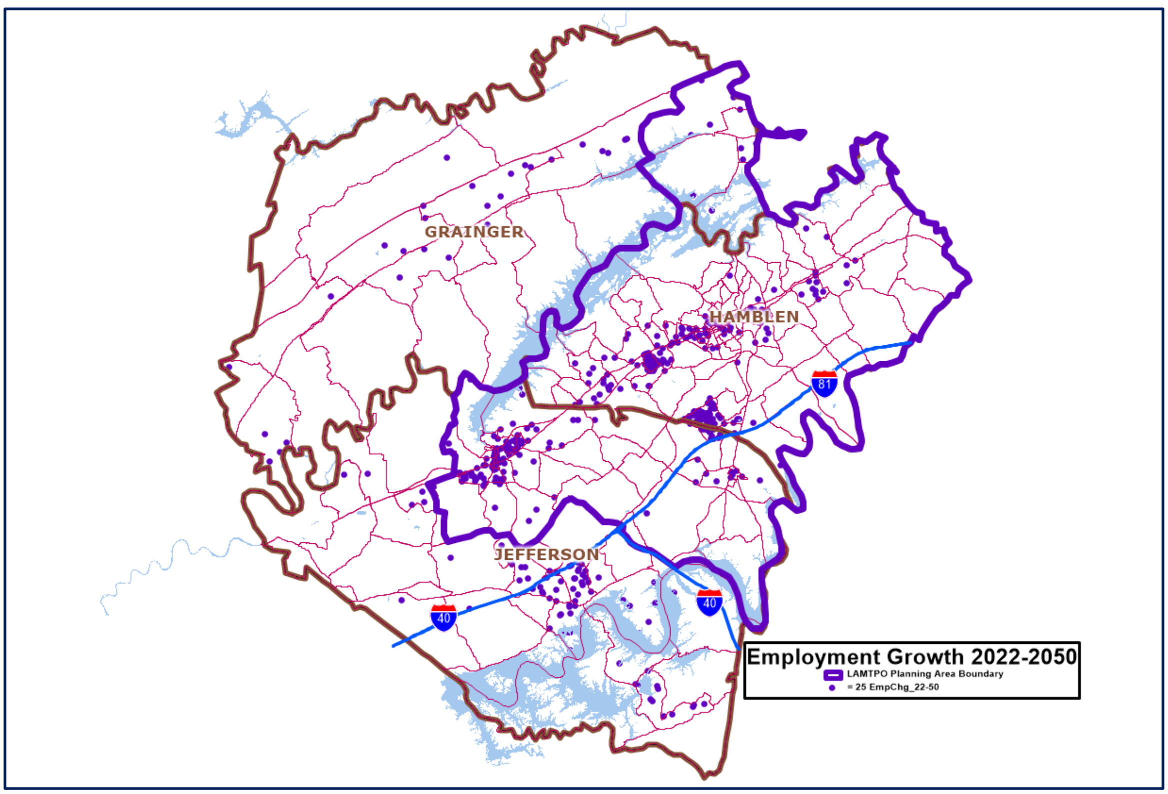

Employment Growth 2022-2050
TPO Planning Area Boundary
= 50 EmpChg_22-50
0
5
10
15
Miles
ANDERSON
KNOX
ROANE
LOUDON
BLOUNT
SEVIER
75
40

Appendix F: LAMTPO Area Future-Year Population and Employment Growth by TAZ






GRAINGER
HAMBLEN
JEFFERSON
81
40
40
2022 Employment by TAZ
LAMTPO Planning Area Boundary
136 and below (105)
137 to 299 (41)
300 to 499 (32)
500 to 779 (14)
780 to 1029 (13)
1030 to 1599 (6)
1600 to 3999 (3)
4000 and above (1)


GRAINGER
HAMBLEN
JEFFERSON
81
40
40
Employment Growth 2022-2050
LAMTPO Planning Area Boundary
= 25 EmpChg_22-50

Final Report for
Travel Demand Forecasting Model Update

Submitted by
Caliper Corporation

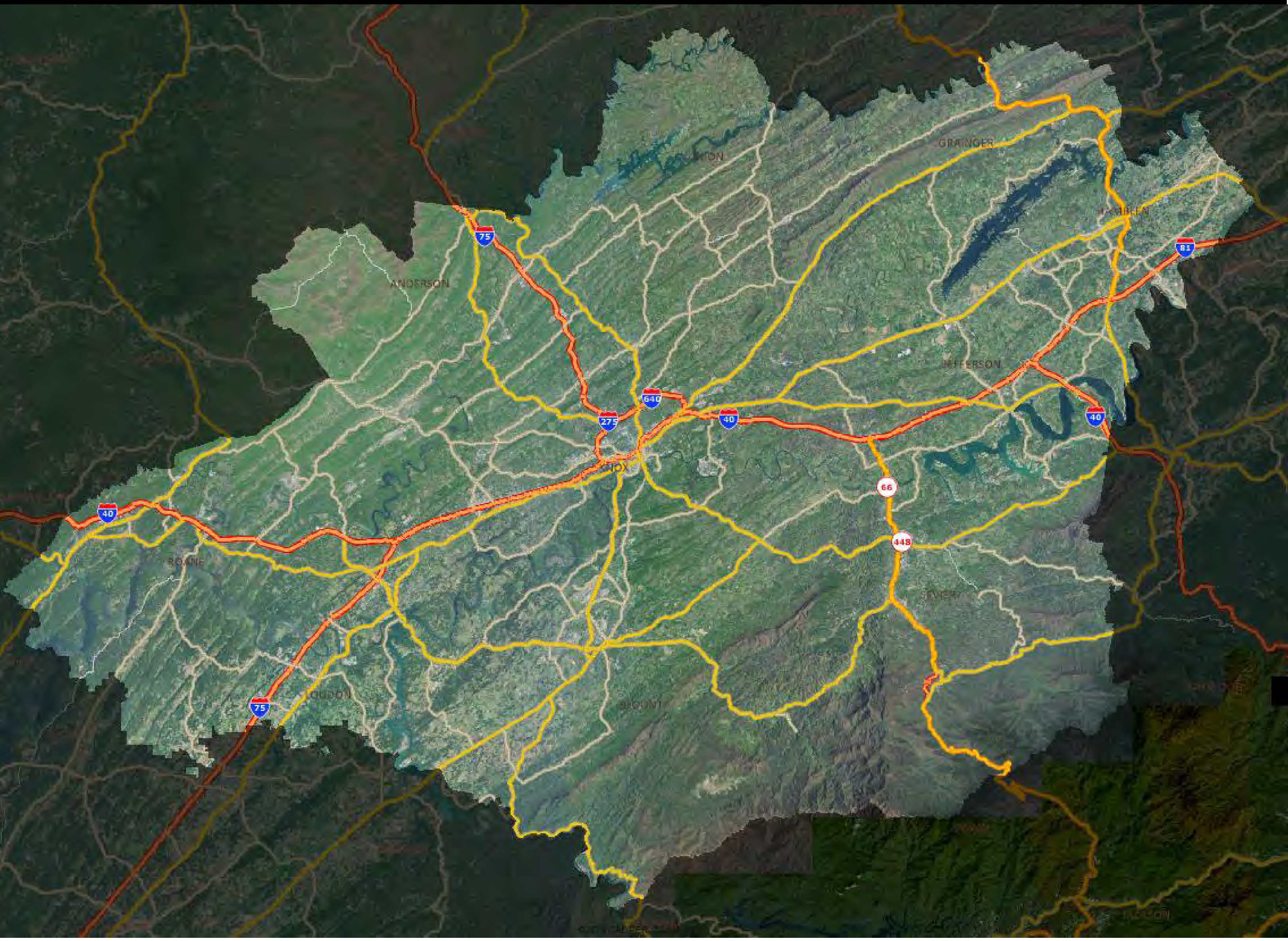


TABLE OF CONTENTS

Introduction

The purpose of this report is to document Caliper Corporation's 2024 recalibration and revalidation of the Knoxville Regional Travel Model (KRTM) for the new base year of 2022.

Background

This is the third update of the version of the KRTM originally developed by Bernardin, Lochmueller & Associates (BLA) in 2009 with a base year of 2006. This original hybrid version of the model was implemented in TransCAD version 5. At the time it was at the very forefront of the practice and represented a major improvement over its predecessor, which was a traditional, four-step sequential trip-based model (also developed by BLA in 2004 and updated in 2008). The hybrid model offered greatly improved policy sensitivity. In particular, the hybrid KRTM offers the following features which its predecessor lacked:

- Sensitivity to fuel prices
- Planning capability for transit, bicycle and pedestrian modes
- More realistic representation of special populations (seniors, low income, students)
- Sensitivity to urban design (mixed uses, development density, grid vs. cul-de-sac style street networks)
- Ability to represent shifts in the timing of travel (due to congestion, aging population, etc.)
- Consistency with tours and trip-chaining behavior
- Improved traffic impacts with halo effects around major developments (malls, factories, etc.)
- More accurate commuting patterns from destination choice models
- Improved representation of speeds and delays from traffic signals, stop signs, etc.
- Improved accuracy of alternatives analysis from new assignment algorithms
- Reduction of aggregation bias which can skew model results

Tour or activity-based models take considerable resources to develop and run. In 2009, most activity-based models took 24-48 hours to run. While computing has improved, many activity-based models still run overnight (~12 hour runtimes). The 2009 KRTM was developed in eight months and ran in less than four hours on a then standard dual core laptop.

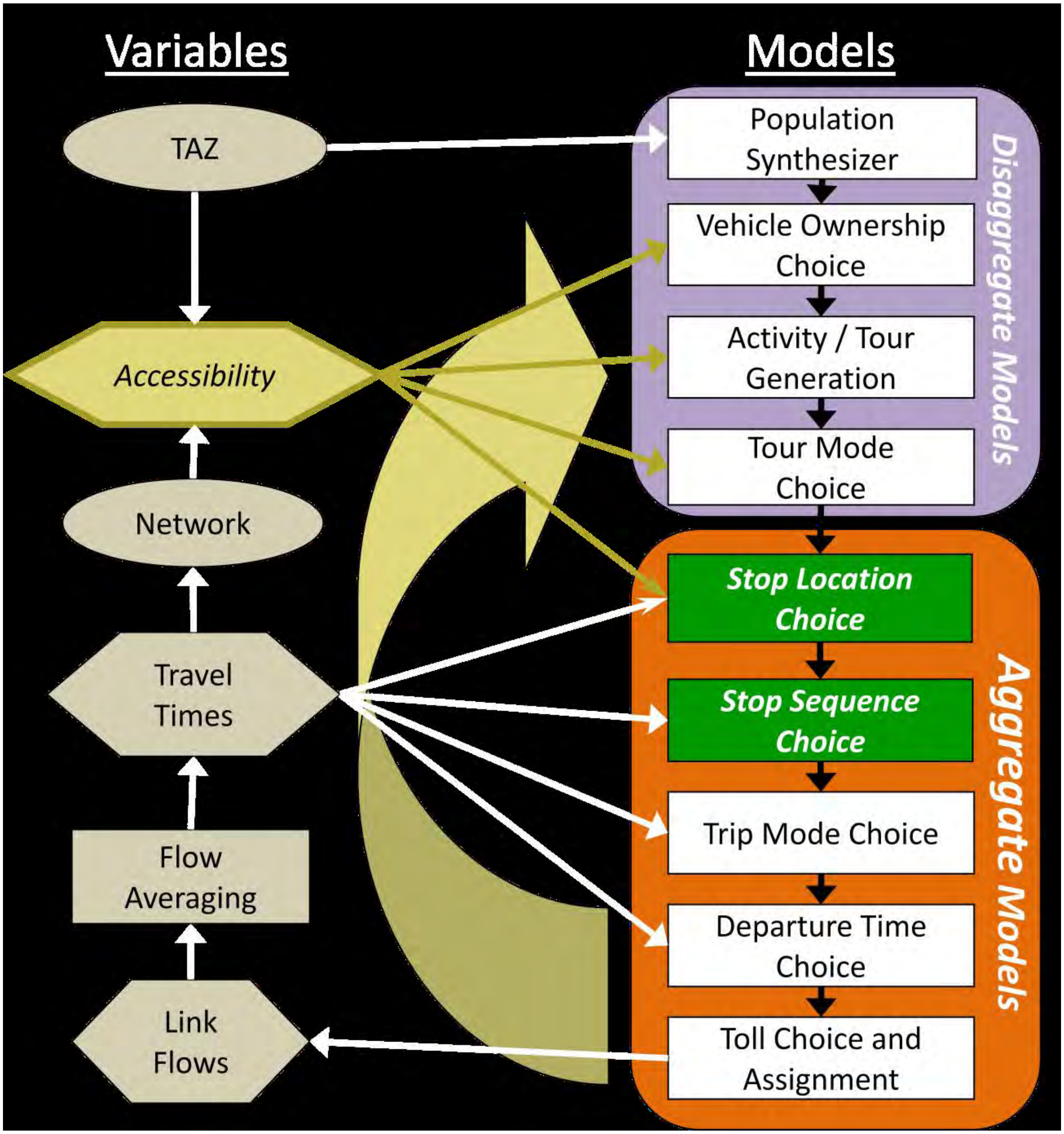


Figure 1. The 2009 KRTM's Hybrid Model Design

The speed of the hybrid KRTM was and is the result of its hybrid design. The architecture was based on based on research conducted by Dr. Vince Bernardin, Jr., as part of his doctoral studies with Profs. Frank Koppelman and David Boyce at Northwestern University and was funded in part by an Eisenhower Fellowship from the Federal Highway Administration. This hybrid model design combines some elements of traditional "four-step" and as well as several components from recent activity-based models, but is ultimately distinct, made possible by the stop location and sequence choice structure original to the hybrid design. While more recent hybrid models have made use of an alternative, slightly simpler method of linking home-based and non-home-based trips, the KRTM paved the way for the development of over 20 hybrid models across the country and the number is still growing.

The KRTM modeling process, illustrated in Figure 1, begins by generating a synthetic population of individual households based on the aggregate characteristics of the population encoded in the traffic analysis zones (TAZ). Then a model predicting households‟ level of vehicle ownership is applied. The number of tours (sojourns beginning and ending at home) of various purposes (work, school, other, etc.) and the number of stops on these tours are predicted for each household. The dominant mode of travel (private automobile, school bus, public bus, walking/biking) is chosen for the household's tours of each purpose. Then, grouping households within the same TAZ together, probable locations of the stops on automobile tours are chosen. Next, for each probable stop location, a preceding location is chosen such that the resulting probable sequences of stops form tours which begin at home and proceed from one stop to the next until returning home. For each trip in the resulting travel pattern, the probability of walking, driving alone or with passengers is predicted, as is the departure time (in 15-minute time periods) and toll-eligibility. Finally, the trips are assigned to the roadway network and routes are chosen such that travelers minimize their travel time and costs. The resulting travel times are used to recalculate accessibility variables, and both are then fed back and used to repeat the process, beginning from the generation of tours and stops, until the changes from one iteration to the next in the resulting roadway volumes are minimal.

The adjective "hybrid" refers to two ways in which the new model design blends aspects of four-step and activity-based models and defies traditional categorization. First, the hybrid KRTM model can be described as trip-based in so far as it essentially produces aggregate trip table matrices of trips between origins and destinations rather than disaggregate records detailing individual travelers' activities. However, hybrid models like the KRTM can also be described as tour-based since the travel patterns they predict can be mathematically proven to be consistent with tours and all travel is segmented within the model by types of tours, eliminating non-home-based trips problematic in traditional models. Hence, models of this design are hybrid trip-based/tour-based models.

Second, perhaps more meaningfully, models like the KRTM are hybrid aggregate/disaggregate models. Unlike four-step models which were entirely aggregate and activity-based models which are entirely disaggregate, the KRTM and similar models include both aggregate and disaggregate component models. Yet despite its inclusion of disaggregate choice models, there are no random number draws or Monte Carlo simulation in the KRTM. As a result, the KRTM‟s model results are reproducible, unlike the results of activity-based or other simulation models. Any difference between two KRTM model runs is directly attributable to differences in their inputs as with traditional trip-based models. Whereas, in simulation models, multiple model runs are necessary when comparing alternatives to ensure that the difference between model runs results from differences in the alternative inputs rather than from differences in the random numbers drawn for each run.

The shift from the disaggregate framework of individual households to the aggregate framework of trips between zones midway through the model distinguishes the hybrid approach. The use of disaggregate components minimizes aggregation bias in the early steps of the model, including the particularly sensitive primary or tour mode choice. At the same time, the approach minimizes model run times by taking advantage of the fact that it is computationally much easier to predict a set of trips which is consistent with tours than to predict the individual tours themselves.

The hybrid approach does have limitations. It lacks the explicit representation offered by activity-based models of the interactions among household members and of constraints in the timing of travel and activities (although these phenomena are still implicit in this framework). However, given its lower development costs and run time and the reproducibility of results, the hybrid model architecture presented a practical and cost-effective way of incorporating more sensitivity and realism in the KRTM to address the TPO's current and future planning issues. For more information on the original hybrid model refer to *Knoxville Regional Travel Model Update 2009: Model Development and Validation Report*.

In 2012 the Knoxville Regional Transportation Planning Organization (TPO) again contracted with BLA to update the KRTM, expanding its geographic coverage to also incorporate the planning region of the Lakeway Area Metropolitan Transportation Planning Organization (LAMTPO). The model was updated to TransCAD 6 with a new base year of 2010. The model was recalibrated and revalidated for the new base year, but no major changes were made to the model structure. For more information on the 2012 model refer to *Knoxville Regional Travel Model Update 2012: Model Development and Validation Report*.

More recently, the Knoxville Regional Transportation Planning Organization (TPO) contracted with Resource Systems Group (RSG) in 2020 to update the model to a new 2018 base year. The KRTM was updated to TransCAD version 8 and revalidated. The model was recalibrated and revalidated for the new base year, but no major changes were made to the model structure. Some minor functionality, was however added to allow the user to decrease trip rates associated with the

COVID pandemic. For more information on the 2012 model refer to the technical memorandum *KRTM Model Revalidation for 2018*, dated October 15, 2020.

Overview

For this third update to the hybrid KRTM, in 2024, the Knoxville Regional Transportation Planning Organization (TPO) contracted with Caliper Corporation to update the KRTM to a post-pandemic base year of 2022. As with the prior updates, no major changes were made to the model structure. A minor change was made to explicitly model remote work from home in order to be able to accurately reflect this phenomenon in the post-pandemic environment. Every major model component was recalibrated, and the model system as a whole was validated against new base year traffic counts. The details of this process are documented in the subsequent sections of this report.

Socioeconomic Data

The 2022 zonal socioeconomic data was developed and provided by the TPO staff using data from the Census Bureau. From the previous base year of 2018, the ten-county region's population grew by 53,466 people to a new 2022 regional population of 1,092,086. Over the same period, the region's total employment grew by 59,365 for a total regional employment of 600,976 in 2022. Growth by county generally reflected the existing distributions of population and employment with the strong majority of the growth in Knox County. However, growth rates varied from under 1% to nearly 13%. See Figures 2 – 4 and Table 1 for population and employment growth by county.

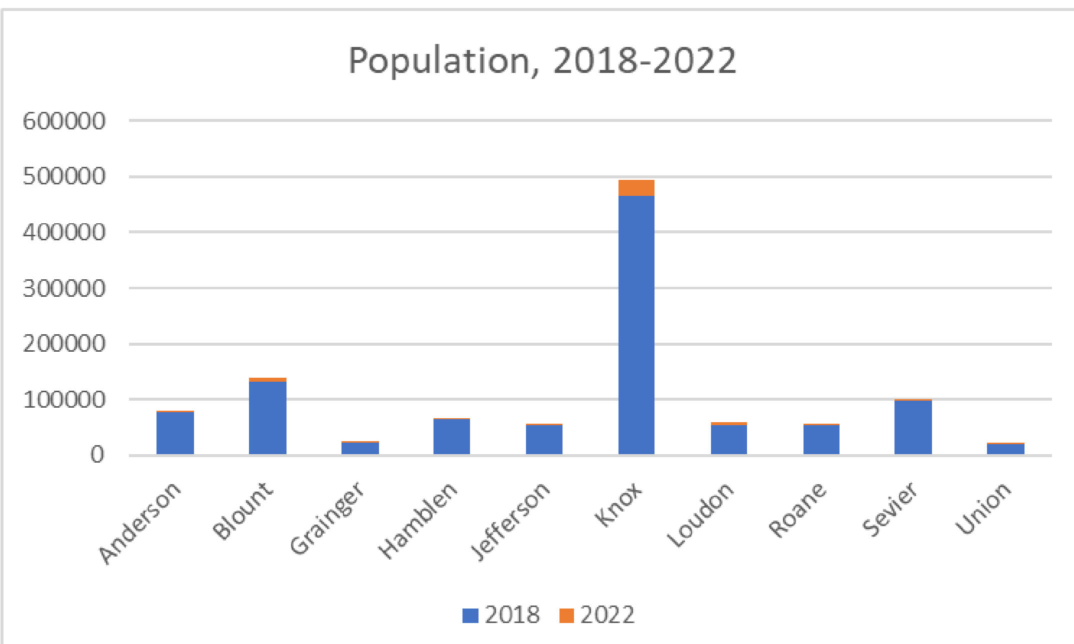


Figure 2. Population by County, 2018 vs. 2022

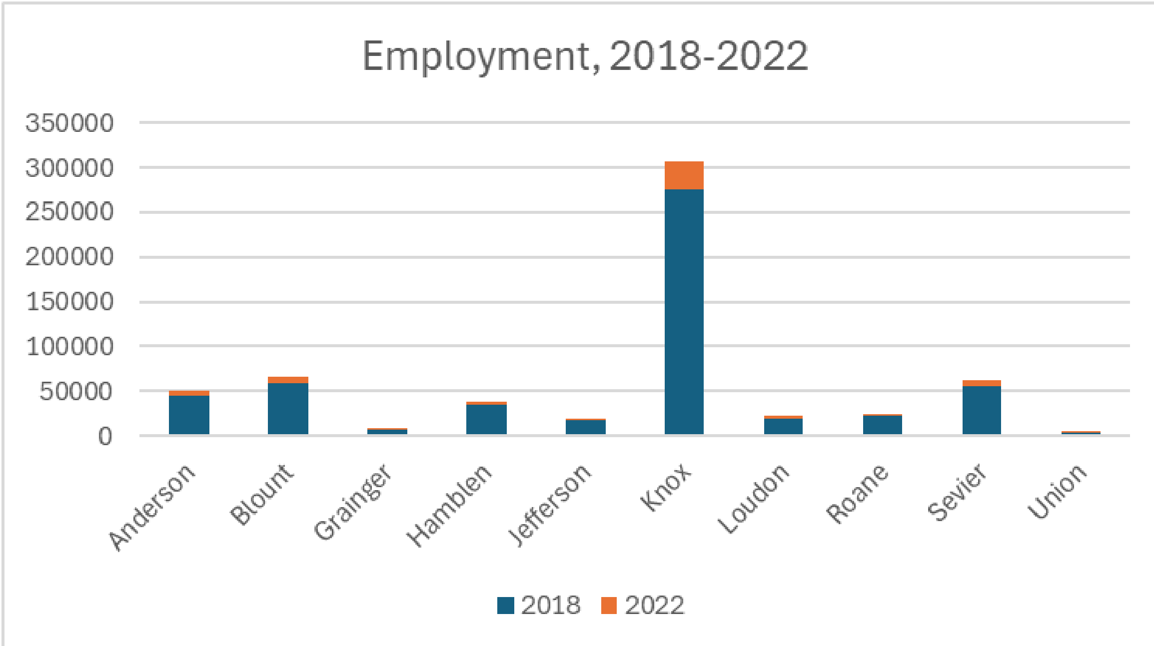


Figure 3. Employment by County, 2018 vs. 2022

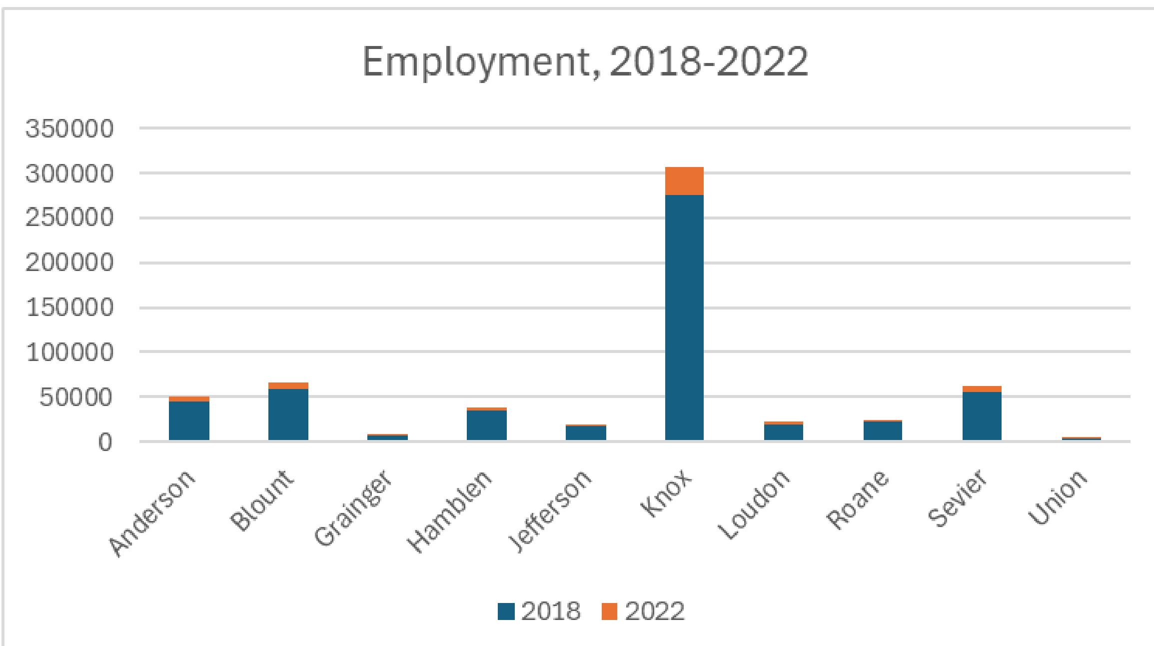

Employment, 2018-2022
350000
300000
250000
200000
150000
100000
50000
0
Anderson
Blount
Grainger
Hamblen
Jefferson
Knox
Loudon
Roane
Sevier
Union
2018
2022

Figure 4. Population and Employment Growth by County

Table 1. Population and Employment Growth by County

County	Population				Employment			
	2018	2022	Growth	Rate	2018	2022	Growth	Rate
Anderson	76,482	78,913	2,431	3.2%	44,399	49,750	5,351	12.1%
Blount	131,349	139,958	8,609	6.6%	59,662	66,473	6,811	11.4%
Grainger	23,145	24,277	1,132	4.9%	6,432	6,760	328	5.1%
Hamblen	64,569	65,168	599	0.9%	35,495	38,475	2,980	8.4%
Jefferson	54,012	56,727	2,715	5.0%	17,371	19,139	1,768	10.2%
Knox	465,289	494,539	29,250	6.3%	276,450	306,232	29,782	10.8%
Loudon	53,054	58,181	5,127	9.7%	19,993	22,540	2,547	12.7%
Roane	53,140	55,082	1,942	3.7%	21,755	24,296	2,541	11.7%
Sevier	97,892	98,789	897	0.9%	55,952	62,834	6,882	12.3%
Union	19,688	20,452	764	3.9%	4,102	4,477	375	9.1%
Total	**1,038,620**	**1,092,086**	**53,466**	**5.1%**	**541,611**	**600,976**	**59,365**	**11.0%**

The distribution of growth at the level of the model's travel analysis zones (TAZ) can be seen in Figures 5 and 6. While there was population growth in every county, with the largest gains in western Knox County and Loudon County, there were some local declines in rural areas and Hamblen County.

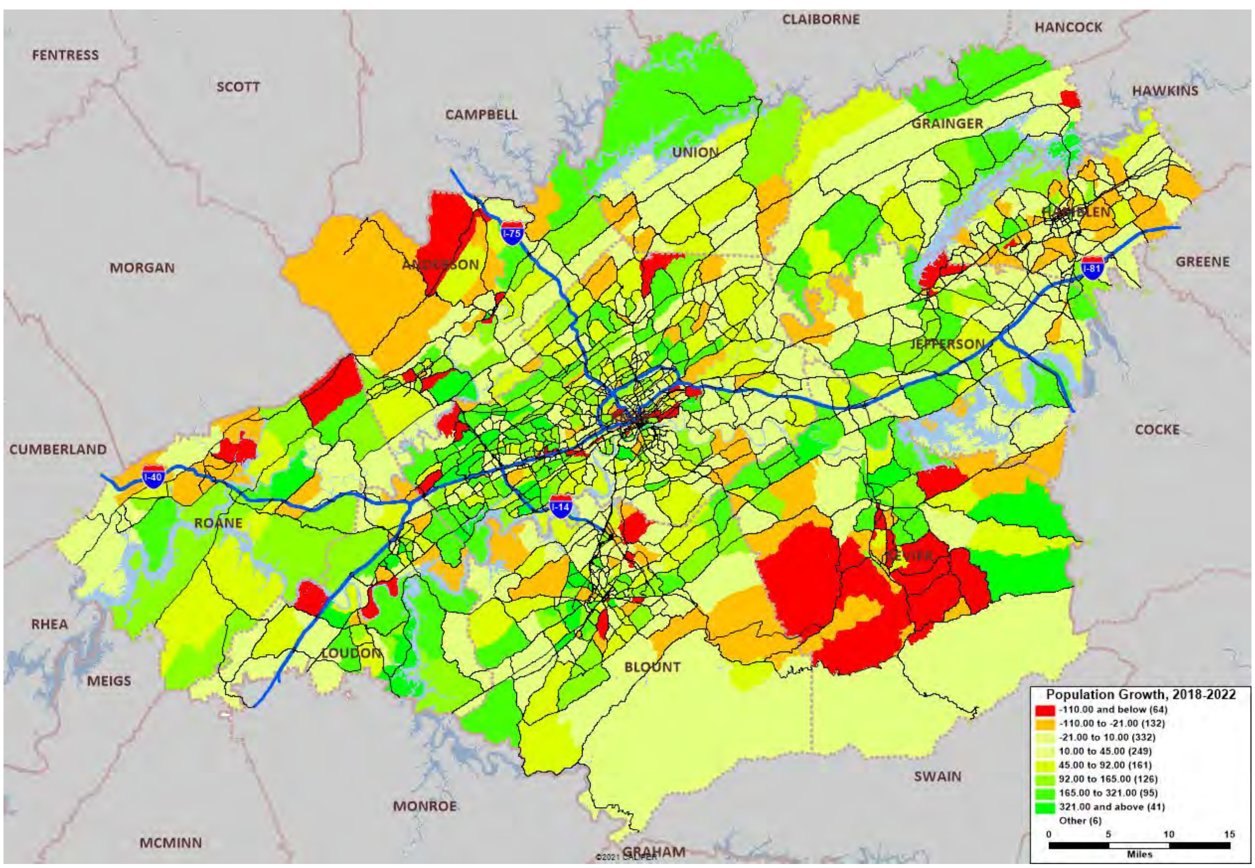


Figure 5. Population Growth by TAZ,, 2018-2022

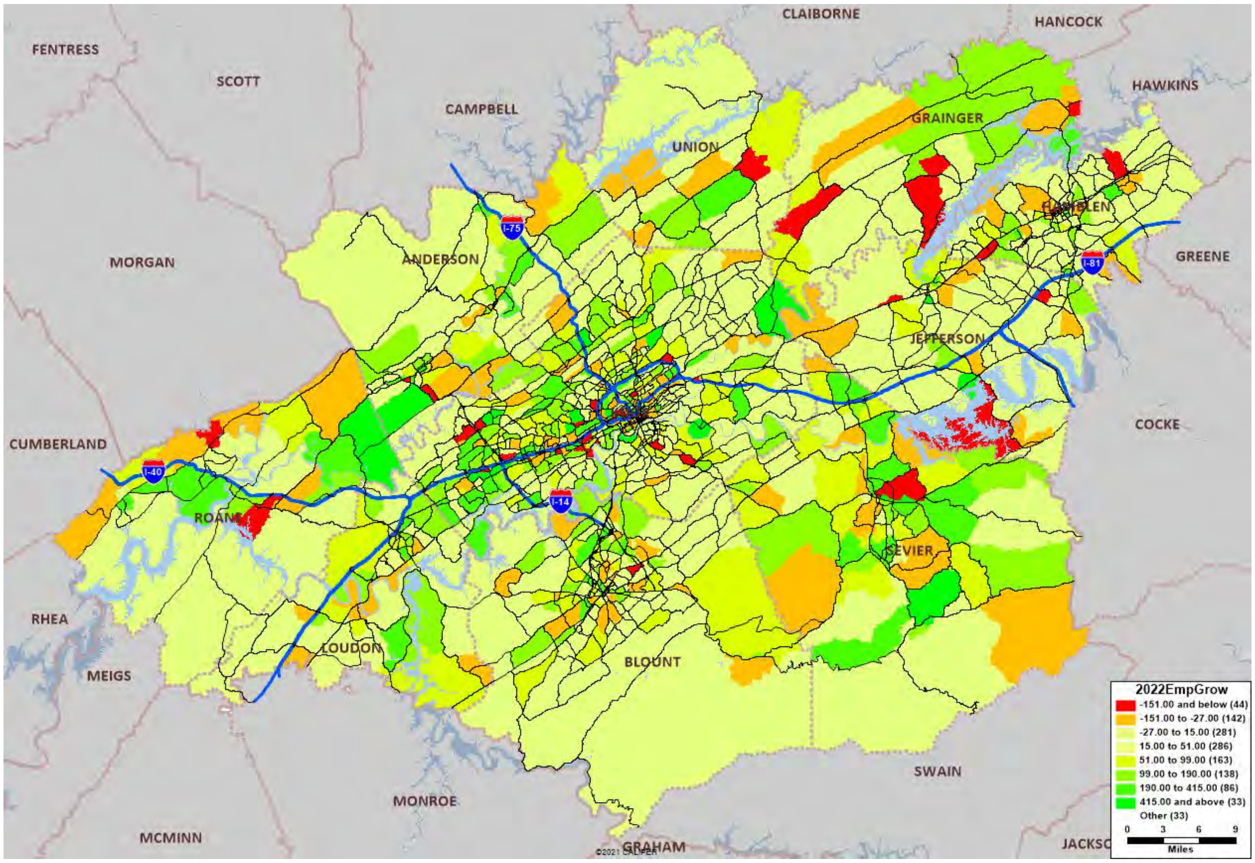


Figure 6. Employment Growth by TAZ, 2018-2022

Employment growth was slightly more dispersed than population growth with significant growth in all counties. Notable growth occurred in southwest Oak Ridge and parts of Sevier County.

While employment determines the location of many trips in the model, the number of trips is driven by the number of workers (by place of residence) as represented by the zonal number of workers per household in the model. Initial estimates of workers per household based on a proprietary dataset were low, with a regional average of 1.14 workers per household, in contrast to 1.24 workers per household in 2018. This represents too much unemployment and too few work tours. Therefore, TPO staff recalculated the workers per household using the actual Census' ACS data and obtained a regional average of 1. 22 workers per household, much more consistent with 2018. All other socio-economic variables appeared reasonable and consistent with previous data.

Tour and Stop Generation

It is evident from household surveys around the country and local traffic count and ACS data that trip-making has changed since the COVID pandemic. In particular, trip-making per capita, measured by tour and stop rates, has decreased. The largest and most notable decrease is associated with work travel where there has been a significant increase in remote work from home. School and other tour rates appear to be largely unaffected, but they have also seen a modest decrease in stops per tour.

Table 2. Regional Tour, Stop, and Trip Rates

		2000 + 2008 Survey	KRTM10	KRTM18	KRTM22
Work Tours		0.94	0.94	1.02	0.88
	Work Stops	1.16	1.16	1.30	1.07
	College Stops	0.03	0.02	0.02	0.02
	Other Stops	0.90	0.88	0.98	0.82
School Tours		0.41	0.49	0.46	0.45
	School Stops	0.42	0.50	0.47	0.46
	Other Stops	0.21	0.22	0.22	0.21
Other Tours		1.48	1.55	1.54	1.54
	Short Maintenance Stops	1.16	1.28	1.27	1.22
	Long Maintenance Stops	0.70	0.80	0.80	0.78
	Discretionary Stops	0.93	0.95	0.98	0.95
Tours/HH/day		2.84	2.98	3.02	2.87
Stops/HH/day		5.52	5.81	6.05	5.53
Trips/HH/day		8.35	8.79	9.07	8.39
Stops/Tour		2.06	1.95	2.00	1.93

It is valuable to look at both the typical travel behavior of individual travelers implied by tour and stop rates as well as the total numbers of tours, stops, and trips resulting from application to the population which has grown over time. Table 2 shows tour, stop, and trip rates from the original combined 2000 and 2008 household surveys used to develop the hybrid KRTM and the last three versions of the model. Prior to this new 2022 version of the KRTM the model's tour and stop rates were always higher than those observed in the survey. This is expected and due to the known phenomenon of under-reporting of trips in household surveys. Work and overall rates were highest in the 2018 model, while non-work rates were highest in the 2010 model. The 2022 model's rates are lower than previous versions of the model, significantly lower work tour and stop rates and just slightly lower school and other tour and trip rates. The non-work tour and stop rates as well as the overall rates remain just slightly higher than the survey rates, while the work tour and stop rates are clearly lower than the survey rates due to the increase in remote work from home. Non-work tour rates are consistent with previous models, although the model shows a slight decrease in stops per tour (which may be explained by the substation of home delivery for shopping stops). The behavior in the model is reasonably consistent with the survey and previous models when allowing for the known increase in remote work from home.

Table 3 shows the total number of tours, stops, and trips in the region in the 2010, 2018, and 2022 base year models. Because the region is growing and the total number of households has been increasing, the number of tours has increased despite the decrease in work tours in 2022 versus 2018. The total number of stops and trips, however, decreased slightly from 2018 to 2022 in the model despite the larger population, due to decreases in the rates. There are clearly two different patterns, one for work travel, and one for non-work travel. Work travel increased from 2010 to 2018, but then fell in 2022. Non-work travel increased across the whole period from 2010 to 2022.

Table 3. Total Tour-, Stop-, and Trip-Making

		KRTM10	KRTM18	KRTM22
Work Tours		370,594	429,732	393,634
	Work Stops	458,234	548,716	477,177
	College Stops	9,188	9,586	8,372
	Other Stops	350,511	412,814	366,477
School Tours		193,056	193,218	200,339
	School Stops	197,535	197,700	204,987
	Other Stops	87,047	91,679	94,920
Other Tours		615,357	646,995	687,944
	Short Maintenance Stops	505,866	533,132	547,357
	Long Maintenance Stops	315,912	336,003	347,011
	Discretionary Stops	378,239	412,961	425,216
Tours/day		1,179,007	1,269,945	1,281,917
Stops/day		2,302,532	2,542,591	2,471,518
Trips/day		3,481,539	3,812,536	3,753,435
Total Households		396,156	420,516	447,242

Remote Work from Home

In order to recognize the phenomenon of remote work from home and to allow the user to test scenarios with higher or lower rates of remote work from home in the future, a simple module was added to change the number of tours and stops generated based on the rate of remote work from home. As the rate of remote work from home increases, the number of work tours and stops decrease; however, non-work stops on work tours shift to become stops on Other Tours. This increase in non-work travel that partially offsets decreases in work travel has been observed in travel surveys and big data during and since the pandemic.

Table 4. Increase in Work from Home in the Census ACS Data

	2022			2010		
	Total Workers	Working from Home		Total Workers	Working from Home	
Knox	251,710	34,030	13.5%	204,933	7,670	3.7%
Anderson	32,457	3,006	9.3%	30,775	730	2.4%
Blount	65,700	10,400	15.8%	55,346	1,652	3.0%
Grainger	9,411	690	7.3%	9,103	408	4.5%
Hamblen	26,689	1,115	4.2%	25,738	810	3.1%
Jefferson	24,606	1,367	5.6%	21,459	578	2.7%
Loudon	24,262	2,318	9.6%	19,648	526	2.7%
Roane	23,119	1,915	8.3%	22,177	630	2.8%
Sevier	45,941	3,241	7.1%	42,033	1,327	3.2%
Union	8,124	743	9.1%	7,360	263	3.6%
All	512,019	58,825	11.5%	438,572	14,594	3.3%

Table 4 shows the increase in remote work from home from 2010 to 2022 in the Census Bureau's American Community Survey (ACS) data for the region. Although not shown in the table, it is important to recognize the uncertainty in these estimates due to the limited sample size of the ACS. It seems clear that for some of the smaller counties in particular (e.g., Grainger and Union in 2010 and Hamblen and perhaps Jefferson in 2022) the small sample size may well have resulted in errors in the rates. However, despite some errors. The pattern of increased work from home is clear and consistent across all counties.

Based on the ACS data, calibration of the 2022 model began from the assumption of 11.5% regional average in remote work from home. However, in validating the model to local traffic counts, it became evident that the ACS data may have under-estimated work from home in the Knoxville region. ACS estimates of work from home for the State of Tennessee (14.0%) and the nation as a whole (15.2%) are higher than those for the Knoxville region and simple sampling error may partially explain the lower regional rate. Therefore, the assumed rate of work from home for the region in 2022 was incrementally increased to 12.5% in the final validated model, still lower than, but slightly closer to the estimate for Tennessee as a whole and to the estimates for Knox and Blount Counties which may be more accurate due to their larger sample size.

Tour Mode Choice

The increase in remote work from home has not been the only recent change in travel behavior. Transit mode share has decreased. It was decreasing slowly prior to the pandemic and since the pandemic has been even lower. Unfortunately, this was not realized in the 2018 update of the model which substantially overpredicted transit ridership. For the 2022 base year update the tour mode choice model was recalibrated to match the ACS work mode shares and transit ridership (as reported in FTA's National Transit Database). ACS data for the region shows that transit mode share for journey to work (work tours) has decreased by nearly 50% from 2010 to 2022. Over that same period, observed KATS ridership has declined 40%. Since ACS only provides information on work tours, transit mode shares for UT, school and other tours must be inferred from total transit ridership. The ridership data suggests that the decrease in work transit trips accounts for the strong majority of the decrease in ridership, but slight decreases in transit mode share for the non-work tour types must have also occurred.

Table 5. Tour Mode Shares

Work Tours							
	Survey	ACS10	KRTM10	ACS18	KRTM18	ACS22	KRTM22
Auto	98.79%	97.86%	98.48%	98.50%	97.05%	98.09%	98.16%
Transit	0.62%	0.54%	0.75%	0.75%	2.15%	0.28%	0.28%
Walk/Bike	0.60%	1.60%	0.78%	0.75%	0.81%	1.62%	1.57%

UT Tours				
	Survey	KRTM10	KRTM18	KRTM22
Auto	90.01%	82.56%	92.03%	87.26%
Transit	1.95%	2.49%	1.34%	4.81%
Walk/Bike	8.05%	14.96%	6.64%	7.94%

School Tours				
	Survey	KRTM10	KRTM18	KRTM22
Auto	81.15%	81.07%	81.51%	81.56%
Transit	0.18%	0.14%	0.54%	0.18%
Walk/Bike	1.07%	1.29%	0.87%	1.09%
School Bus	17.59%	17.51%	17.09%	17.17%

Other Tours				
	Survey	KRTM10	KRTM18	KRTM22
Auto	98.19%	97.84%	98.19%	98.13%
Transit	0.10%	0.12%	0.33%	0.11%
Walk/Bike	1.71%	2.04%	1.48%	1.77%

Table 5 shows tour mode shares from the original combined 2000 and 2008 survey, and ACS and model results for 2010, 2018, and 2022. The mode shares in the KRTM generally reflect the mode shares in the original survey used to develop it. However, the KRTM 2022 has been recalibrated, primarily to match the latest ACS data on work tour mode shares. Table 6 shows the total KATS ridership over time both as modeled by the KRTM and reported by FTA. In 2010 the KRTM's ridership was about 10% higher than reported. In 2018, the model was not well calibrated for transit ridership, estimating over four times too much ridership. The 2022 KRTM has been recalibrated to match observed ridership (in linked trips).

Table 6. KATS System Ridership

Transit Ridership	2010	2018	2022
Modeled	10,126	31,279	6,149
Observed	9,194	7,217	6,225

The updated tour mode choice also reflects updated input variables for 2022. Since the 2010 model, the KRTM has been calibrated to use year 2010 dollars, so bus fares and gas prices must be adjusted for inflation. KATS fares have decreased in both nominal and real dollars. KATS single trip fare is now $1 which is only $0.75 in year 2010 dollars. As can be seen in Figure 7, gas prices are always fluctuating, and gas prices experienced a minor spike from March to August of 2022, but over the whole of 2022, they averaged about $3.60/gallon in current year dollars. Converting to year 2010 dollars this comes to a price of $2.65/gallon. As Knoxville gas prices have averaged something more like $3.10/gallon through 2023 and early 2024 ($2.21 in year 2010 dollars), it may be reasonable to use a lower gas price along these lines in forecasting as with the exception of the 2022 spike, local gas prices have been reasonably flat over the past decade (see Figure 8).

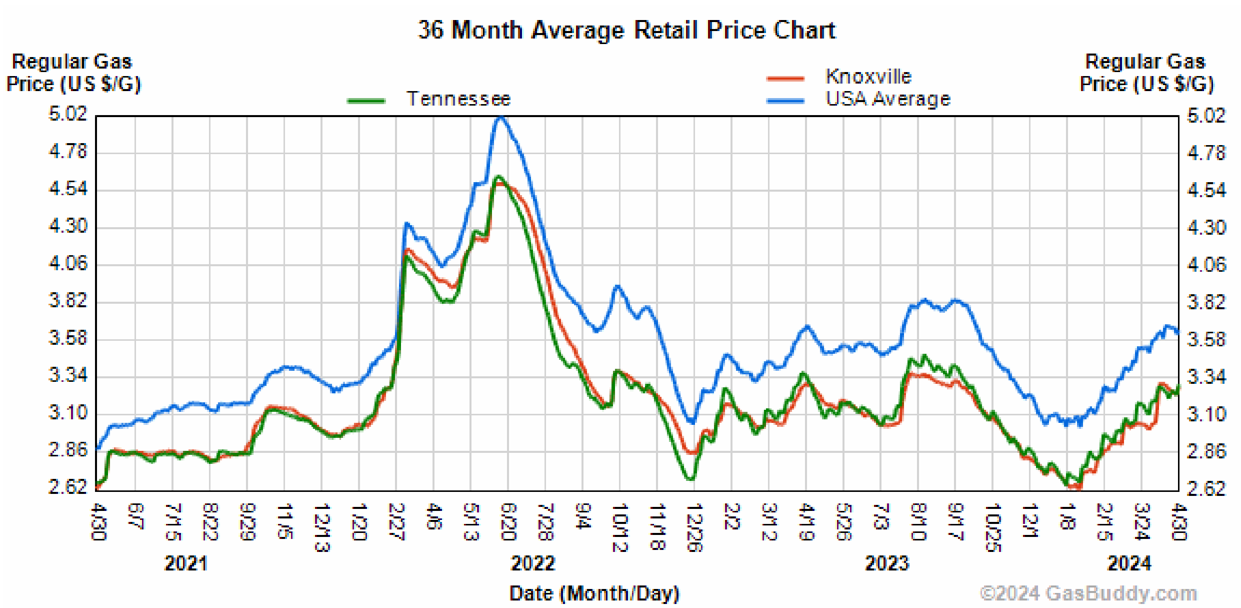


Figure 7. Knoxville Gas Prices 2021-2024 (GasBuddy.com)

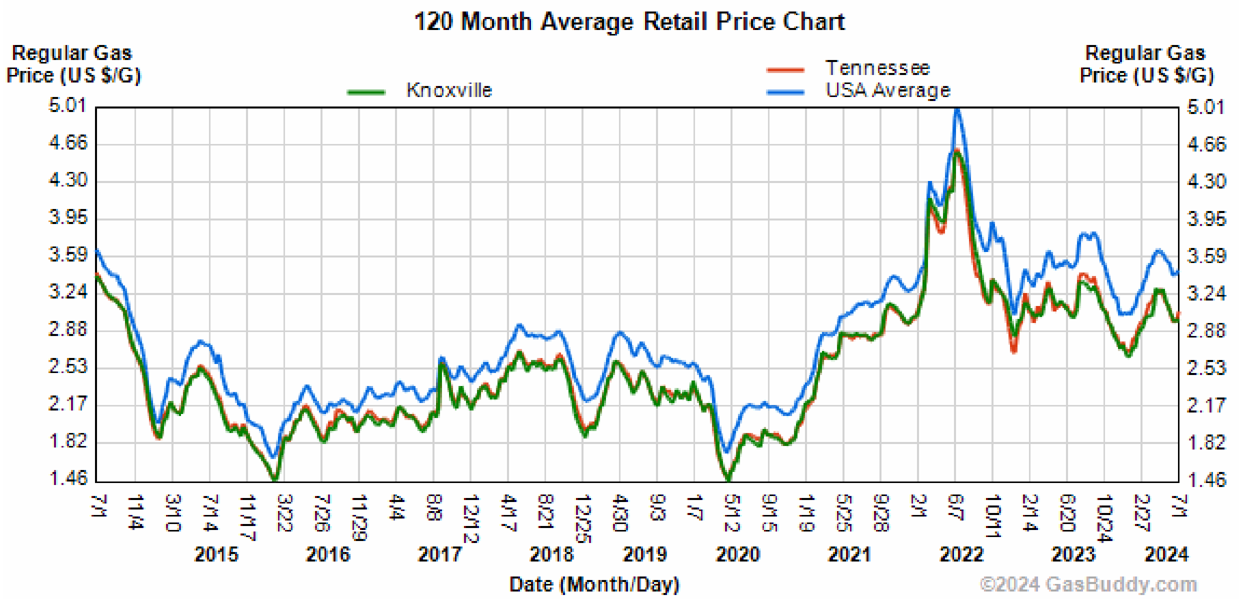


Figure 8. Knoxville Gas Prices over the Past Decade (GasBuddy.com)

Stop Location Choice

Stop location choice or destination choice is not expected to have changed significantly from prior to the pandemic, although new survey data would help to confirm this or measure any changes that have occurred. However, some adjustments to the model parameters were necessary in order to reproduce observed travel times from home and intrazonal percentages from the original survey. As in the prior updates, the main adjustment was to the parameters for residential accessibility interacted with travel time and the intrazonal parameter; however, as it was observed that county cutlines and river crossings were high versus counts, the parameters for the impact of these psychological barriers were increased. A 60% increase in the river crossing effect and a 65% increase in the county line crossing effect achieved better agreements of the resulting assignment with counts. However, the actual increase in terms of equivalent time for these barriers increased by less than these proportions since the impedance parameters also increased. Table 7 shows that updated model is well calibrated to the original survey data. However, given the need to adjust the model parameters, it is recommended that the next model update be based on new data.

Table 7. Comparison of Observed and Modeled Travel Times and Percent Intrazonal

		Mean Travel Time from Home		Intrazonal Percentage	
Work Tours		Observed	Modeled	Observed	Modeled
	Work (Low Income)	15.3	15.4	3.3	3.1
	Work Stops	18.5	18.7	3.0	3.3
	College Stops	20.8	20.8	0.0	0.4
	Other Stops	14.6	14.9	4.2	4.0
UT Tours					
	Other Stops	15.9	15.7	4.2	3.7
School Tours					
	School Stops	10.1	9.8	11.3	11.3
	Other Stops	12.4	12.9	8.8	5.6
Other Tours					
	Short Maintenance Stops	11.7	11.7	7.6	7.7
	Long Maintenance Stops	15.0	15.1	3.4	3.6
	Discretionary Stops	14.2	14.4	6.6	6.8

Stop Sequence Choice

The second spatial choice model in the KRTM which ensures the consistency of its trip tables with tours is stop sequence choice. In this model, the home locations and stops from stop location choice are connected to form trips consistent with closed tours. The goodness-of-fit of these models is determined by comparing the observed and modeled trip lengths (in travel time) and percent diagonal or intrazonal. For each tour time home-based and non-home-based trips can be separately compared though they are produced by the same model. As Table 8 shows, the updated model reproduces the observed trip characteristics from the original survey very well, and notably better than the previous updates, particularly regarding intrazonals.

Table 8. Observed and Modeled Trip Lengths and Percent Intrazonal

	.				Percent Diagonal			
Trip Type	Observed	KRTM10	KRTM18	KRTM22	Observed	KRTM10	KRTM18	KRTM22
Work Tours	14.9	14.5	14.7	15.0	5.1	4.0		5.2
Work Tours - Home-Based	16.3	16.1	16.5	16.4	4.1	5.0		4.2
Work Tours - Non-Home	12.4	11.7	11.7	12.5	7.0	2.1		6.9
UT Tours	15.0	10.6	11.2	15.2	1.2	1.6		1.7
UT Tours - Home-Base	16.3	10.8	11.4	16.3	0.6	2.0		1.4
UT Tours - Non-Home	12.1	9.9	10.5	12.6	2.7	0.3		2.2
School Tours	10.5	10.5	10.5	10.5	10.7	8.8		10.9
School Tours - Home-Based	10.3	10.2	10.3	10.4	11.0	10.3		11.1
School Tours - Non-Home	11.2	12.2	11.9	11.1	9.8	0.6		9.8
Other Tours	12.1	11.9	12.0	12.3	8.5	5.5		8.8
Other Tours - Home-Based	12.7	12.7	12.5	12.6	7.6	7.4		8.5
Other Tours - Non-Home	10.6	9.9	9.5	10.6	10.8	1.2		10.6

The final distribution of passenger trips for the region, reflecting the combined results of stop location and stop sequence choices, was also validated by comparing the final total passenger origin-destination (OD) trips with the distributions observed in the combined 2000-2008 survey and the 2022 Transography data. The tables below compare the aggregate county-to-county OD flows. To facilitate comparison because Hamblen and Grainger counties were not included in the survey data, they have been omitted in all the tables.

Table 9. All trips from the 2000-2008 survey

	Anderson	Blount	Jefferson	Knox	Loudon	Roane	Sevier	Union
Anderson	7.9%	0.0%	0.0%	1.1%	0.0%	0.8%	0.0%	0.0%
Blount	0.0%	9.9%	0.0%	1.7%	0.2%	0.0%	0.2%	0.0%
Jefferson	0.0%	0.0%	3.8%	0.3%	0.0%	0.0%	0.1%	0.0%
Knox	1.1%	1.7%	0.3%	49.3%	0.6%	0.3%	0.9%	0.4%
Loudon	0.0%	0.1%	0.0%	0.6%	4.0%	0.2%	0.0%	0.0%
Roane	0.7%	0.1%	0.0%	0.3%	0.2%	3.3%	0.0%	0.0%
Sevier	0.0%	0.2%	0.1%	0.9%	0.0%	0.0%	6.9%	0.0%
Union	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.9%

Table 10. All trips from the 2023 Transography data

	Anderson	Blount	Jefferson	Knox	Loudon	Roane	Sevier	Union
Anderson	6.8%	0.1%	0.0%	1.0%	0.0%	0.3%	0.0%	0.0%
Blount	0.1%	12.0%	0.0%	1.2%	0.2%	0.0%	0.3%	0.0%
Jefferson	0.0%	0.0%	3.1%	0.3%	0.0%	0.0%	0.2%	0.0%
Knox	1.0%	1.2%	0.3%	48.2%	0.6%	0.2%	0.6%	0.2%
Loudon	0.0%	0.2%	0.0%	0.6%	3.9%	0.1%	0.0%	0.0%
Roane	0.3%	0.0%	0.0%	0.2%	0.1%	3.6%	0.0%	0.0%
Sevier	0.0%	0.3%	0.2%	0.6%	0.0%	0.0%	10.5%	0.0%
Union	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.8%

Table 11. All trips from the 2022 KRTM

	Anderson	Blount	Jefferson	Knox	Loudon	Roane	Sevier	Union
Anderson	5.2%	0.0%	0.0%	1.5%	0.0%	0.4%	0.0%	0.1%
Blount	0.0%	12.0%	0.0%	1.6%	0.3%	0.0%	0.4%	0.0%
Jefferson	0.0%	0.0%	2.6%	0.3%	0.0%	0.0%	0.3%	0.0%
Knox	1.6%	1.6%	0.3%	47.1%	1.0%	0.4%	1.0%	0.4%
Loudon	0.0%	0.3%	0.0%	1.0%	2.7%	0.2%	0.0%	0.0%
Roane	0.4%	0.0%	0.0%	0.4%	0.2%	3.0%	0.0%	0.0%
Sevier	0.0%	0.4%	0.3%	0.7%	0.0%	0.0%	11.0%	0.0%
Union	0.1%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.8%

All the sources agree that the majority of trips are intra-county, with just under half of all trips in the region occurring entirely within Knox County. The 2022 KRTM's distribution matches the 2022 Transography data slightly better than the 2000-2008 survey distribution, perhaps indicating that the model is accurately reflecting some real, albeit minor changes in OD patterns in the region. The KRTM appears it may be slightly high on inter-county trips and slightly low on intra-county trips, but the error is small. Re-estimating the county boundary psychological barrier term from new data would be expected to fix this in a new model.

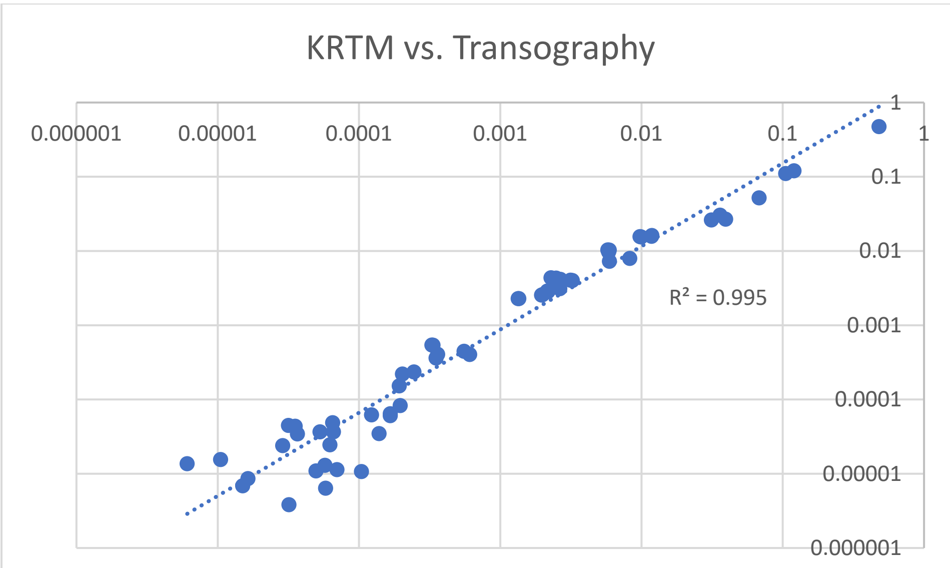


Figure 9. County-to-County OD flows, KRTM vs. Transography

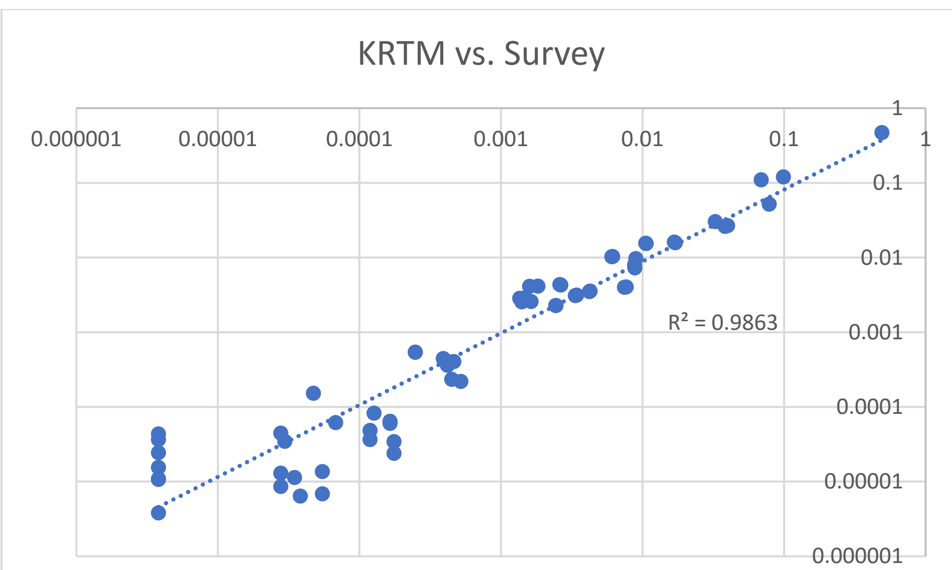


Figure 10. County-to-County OD flows, KRTM vs. Survey

Because the county-to-county flows are dominated by intra-county trips, it is also helpful to look at just the inter-county trip patterns. Again, it is clear that all three sources present basically the same pattern. The model appears to be doing a very good job of reproducing observed flows at least at a high level.

Table 12. Intercounty OD flows from 2000-2008 Survey

	Anderson	Blount	Jefferson	Knox	Loudon	Roane	Sevier	Union
Anderson		0.3%	0.1%	7.6%	0.3%	5.5%	0.0%	0.2%
Blount	0.3%		0.1%	12.2%	1.2%	0.3%	1.3%	0.0%
Jefferson	0.1%	0.1%		2.4%	0.0%	0.0%	1.0%	0.0%
Knox	7.6%	12.0%	2.5%		4.4%	1.9%	6.4%	3.1%
Loudon	0.3%	1.0%	0.0%	4.4%		1.7%	0.0%	0.0%
Roane	5.4%	0.4%	0.0%	1.9%	1.8%		0.0%	0.0%
Sevier	0.1%	1.1%	1.1%	6.3%	0.0%	0.0%		0.1%
Union	0.2%	0.0%	0.0%	3.0%	0.0%	0.0%	0.1%	

Table 13. Intercounty OD flows from 2022 Transogpraphy data

	Anderson	Blount	Jefferson	Knox	Loudon	Roane	Sevier	Union
Anderson		0.6%	0.1%	9.1%	0.3%	2.9%	0.2%	0.3%
Blount	0.5%		0.2%	10.8%	1.8%	0.2%	2.4%	0.1%
Jefferson	0.1%	0.2%		2.4%	0.1%	0.1%	2.0%	0.0%
Knox	8.9%	10.8%	2.4%		5.3%	2.3%	5.4%	2.3%
Loudon	0.3%	1.8%	0.0%	5.4%		1.2%	0.1%	0.0%
Roane	3.0%	0.2%	0.0%	2.1%	1.2%		0.1%	0.0%
Sevier	0.2%	2.4%	2.0%	5.4%	0.1%	0.1%		0.0%
Union	0.3%	0.0%	0.0%	2.3%	0.0%	0.0%	0.0%	

Table 14. Intercounty OD flows from 2022 KRTM

	Anderson	Blount	Jefferson	Knox	Loudon	Roane	Sevier	Union
Anderson		0.3%	0.0%	9.8%	0.2%	2.6%	0.1%	0.3%
Blount	0.3%		0.0%	10.0%	1.6%	0.1%	2.6%	0.0%
Jefferson	0.0%	0.0%		2.0%	0.0%	0.0%	1.8%	0.0%
Knox	9.9%	10.2%	2.0%		6.5%	2.7%	6.1%	2.3%
Loudon	0.3%	1.6%	0.0%	6.5%		1.4%	0.0%	0.0%
Roane	2.5%	0.1%	0.0%	2.7%	1.4%		0.0%	0.0%
Sevier	0.1%	2.6%	1.8%	4.6%	0.0%	0.0%		0.0%
Union	0.3%	0.0%	0.0%	2.2%	0.0%	0.0%	0.0%	

External Trips

The KRTM's external trips were also updated using the 2022 Transography data. This is the first time new data has been available to update the model's external trips since the 2009 model development. The new data shows both similarities and differences in the external travel patterns for the region.

Based on the 2007 license plate matching study, 19% of all external trips were through trips. However, given the loose limit on elapsed time between the captures this includes trips that made a stop (i.e., for gas or food) in the region. The Transography commercial vehicle data, on the other hand, considers trips making a stop within the region as an EI and an IE trip (two trips) rather than a single, through EE trip. For that reason, the Transography data shows 10.5% of external trips as through trips. However, since the model was designed for the looser definition of through trips, the EE trips from Transography were scaled up to be loosely consistent with the previous level of through trips.

Both datasets show the dominance of the interstates, but the 2022 Transography data shows the I-75 through movement as more dominant; whereas, the 2007 license place study, the I-75 and I-40 through movements and exchanges were more balanced in magnitude. The difference is meaningful, but not necessarily implausible suggesting some real change in long distance travel patterns through the region. The 2022 KRTM accordingly reflects the newer data.

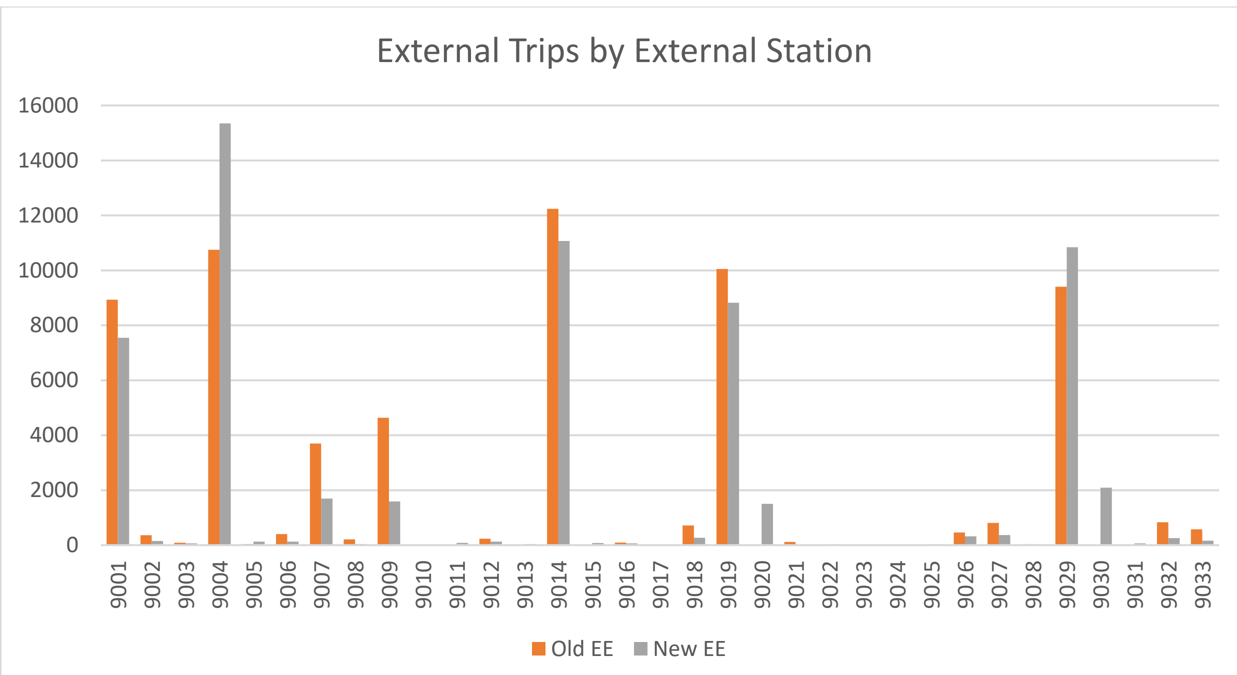


Figure 11. External Trips by External Station

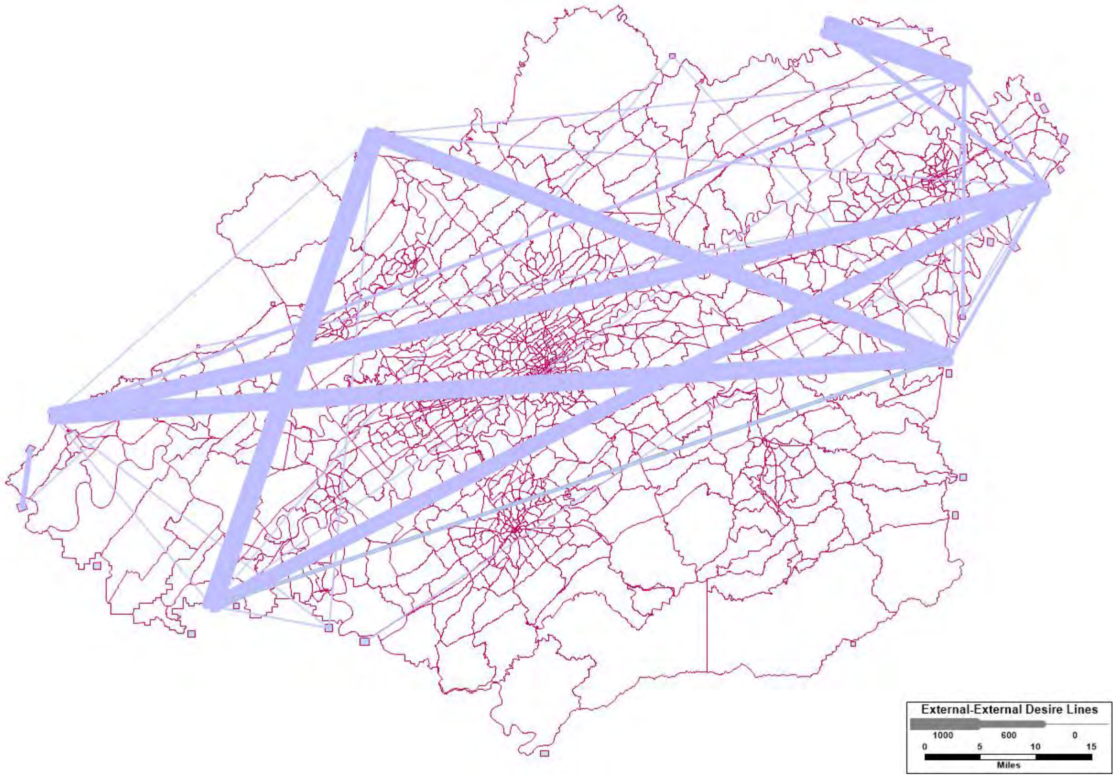


Figure 12. EE Desire Lines based on 2007 Survey

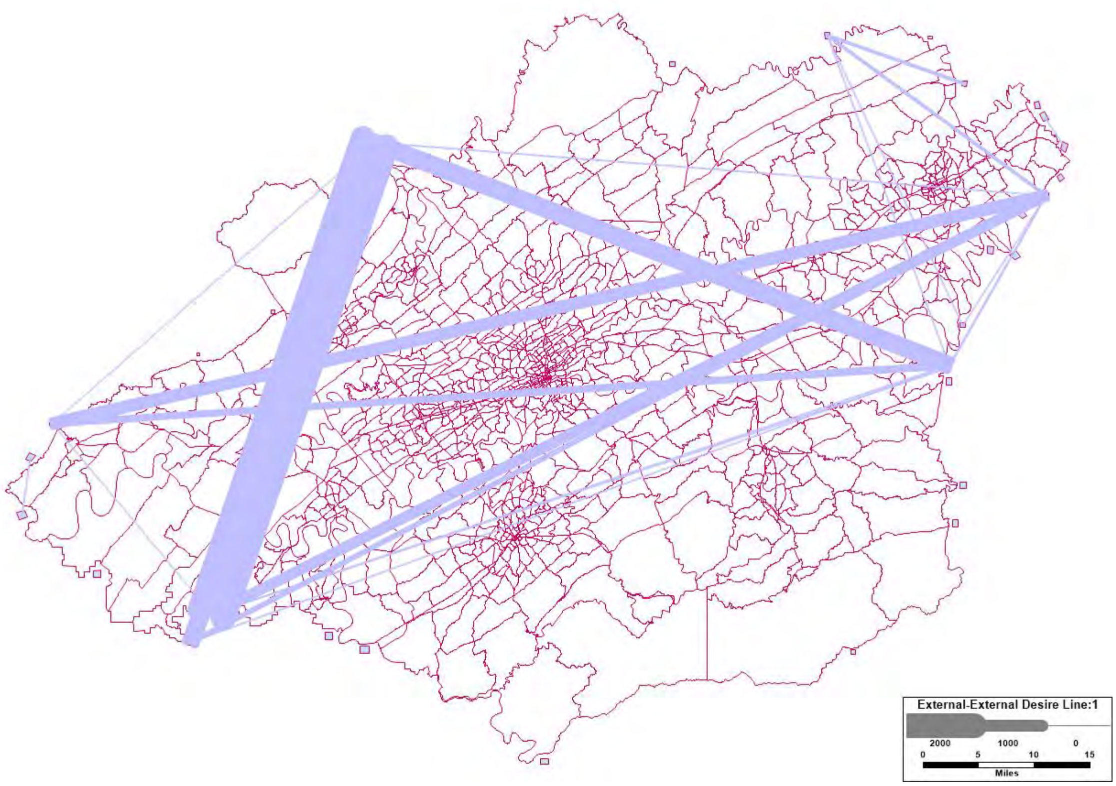


Figure 13. EE Desire Lines based on 2022 Transography data

Table 15. External Trip Time-of-Day Distributions

	All External Cars 2007	EE 2022	EI 2022
AM	7.82%	10.51%	11.89%
PM	20.75%	21.96%	23.24%
OP	71.43%	67.54%	64.87%

The Transography data was also used to estimate new time-of-day factors for external trips. Again, as in the geographic patterns, there was overall similarity, but also some differences between the 2007 and 2022 data. The 2022 KRTM reflects slightly more external traffic in the AM and PM peak periods, although the majority of external trips remain in the off-peak period.

Assignment Validation

In the final step of the travel model, the vehicle trip tables for each class are assigned to the model network. External automobile trips and single and multiple unit trucks are loaded first, on the assumption that they do not divert do to congestion. Then, local automobile trips are assigned routes through the network on the "user equilibrium" assumption that only minimum congested travel cost routes are used. The Knoxville regional model makes use of TransCAD 9.0's origin-based algorithm to solve for the user equilibrium solution to a high level of precision (0.0001 relative gap). More precise or more tightly converged assignment solutions are more stable and have more localized sensitivity.

The CAL_REP module was used to create maps with a color theme based on loading error and a scaled symbol/width theme on absolute error as well as to report model performance for the:

- network as a whole,
- functional classes,
- volume group ranges,
- designated screenlines,
- designated corridors,
- area types, and
- counties.

The assignment loading error map is shown in Figure 14. As can be seen, the loading errors are generally randomly distributed, indicating that systematic errors have been addressed in calibration.

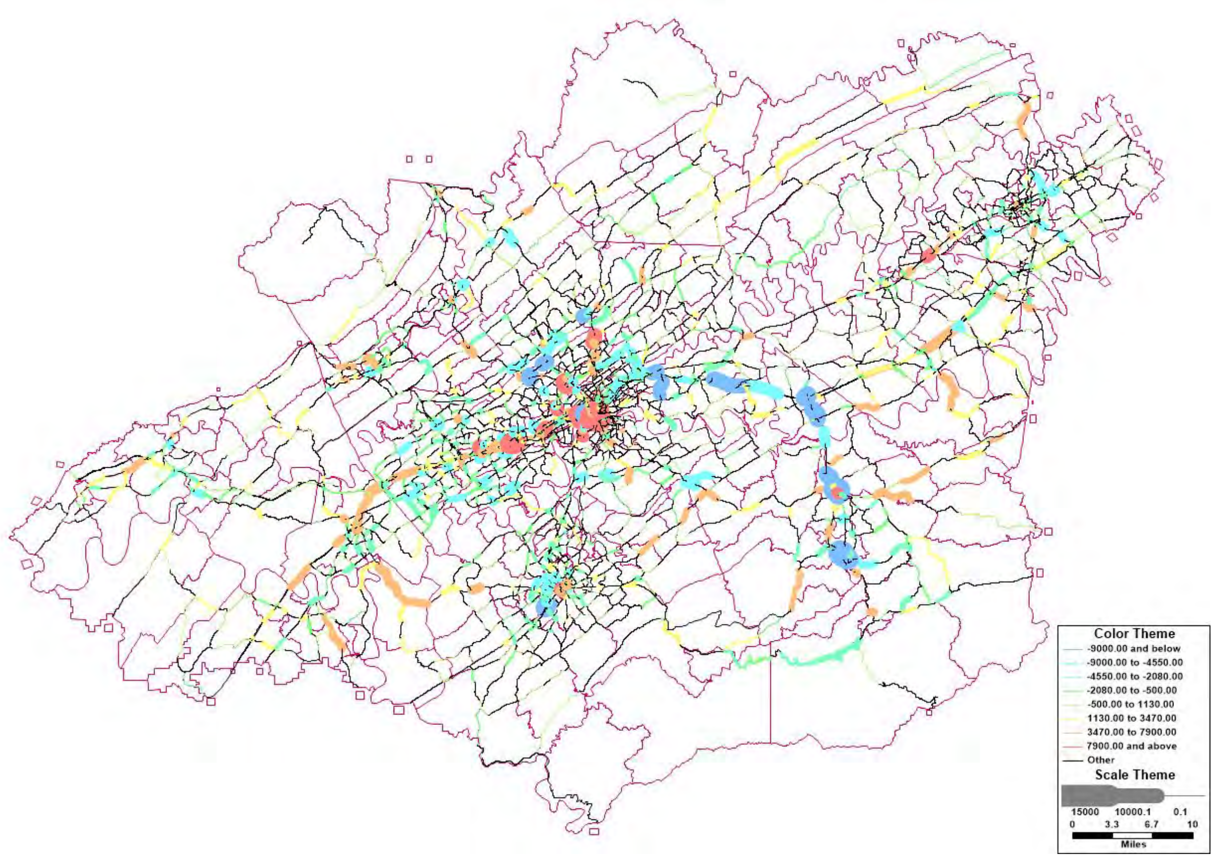


Figure 14. Model Loading Errors

Error statistics reported and used for diagnosing the possible sources of model error are:

- percent root mean square errors,
- systemwide average error,
- mean loading errors and percentage errors, and
- total VMT and percentage errors.

Attention is always needed to the traffic counts, themselves, since the validation is only as good as the counts. In the course of the model's validation, several suspicious counts were identified and removed or corrected in coordination with the TPO and TDOT. Arterial and collector counts appeared to be fine, but freeway counts appeared to have issues. This has been the case in at least the last four model validations for the region going back to at least 2004. The two issues which have indicated issues with the freeway counts have been large year-to-year variations and inconsistencies of counts at interchanges (where the sum of the counts going into a link do not equal the value of the count on the link). As in the past, suspicious freeway counts were reviewed and revised to improve their consistency with other counts (upsteam and downsteam as well as across years). Roughly one third (57 of 176) of all freeway counts were revised. The average adjustment was just over 1,700 or just under 5% of the count value. Thus, the adjustments were generally not large, but they were significant.

The Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee Updated 2016 identifies several guidelines for demonstrating that a model is well calibrated. However, as the document itself is clear to state, the fulfillment of these guidelines does not ensure that a model is well validated nor does the failure of a model to meet every target or standard mean the model is necessarily not well calibrated. The tables below correspond to the standards adopted by TNMUG. In each case they compare the modeled traffic volumes to observed traffic counts. A variety of error statistics are used. Most of the guidelines focus on the simple Percent Error.

Table 16 shows the three standards based on percent difference in value (by classification, by volume group, and by screenline). The model clearly meets all the standards (including preferred) with the exception of one sceenline which exceeds the standard by less than half a percent. This represents very good fit.

Table 16. Percent Difference in Volume Standards

Classification	Acceptable	Preferred	Model Value	Pass / Fail	Average Count	Average Modeled	Number of Observations
Freeways	7%	6%	1.9%	Pass	17,376	17,576	447
Arterials	15%	10%	-2.4%	Pass	14,277	13,920	601
Collectors	25%	20%	-11.5%	Pass	3,688	3,300	1,211
Volume Group	**Acceptable**	**Preferred**	**Model Value**	**Pass / Fail**	**Average Count**	**Average Modeled**	**Number of Observations**
0 - 1000	200%	60%	45.6%	Pass	634	947	188
1001 - 2,500	100%	47%	-3.6%	Pass	1,721	1,810	332
2,501 - 5,000	50%	36%	-0.5%	Pass	3,626	3,620	330
5,001 - 10,000	29%	25%	-4.5%	Pass	7,192	6,876	395
10,001 - 25,000	25%	20%	-2.2%	Pass	15,903	15,534	400
25,001 - 50,000	22%	15%	-1.3%	Pass	33,426	32,777	172
> 50,000	21%	10%	-0.6%	Pass	71,964	71,010	32
Screenline	**Standard**		**Model Value**	**Pass / Fail**	**Average Count**	**Average Modeled**	**Number of Observations**
External	1%		0.6%	Pass	10,304	10,241	33
Knox+Blount	10%		5.9%	Pass	12,913	13,448	21
Knox	10%		6.8%	Pass	19,942	21,157	39
Blount	10%		2.1%	Pass	11,722	12,002	10
Rivers	10%		7.2%	Pass	18,451	19,676	19

InnerKnoxville	10%	6.6%	Pass	24,847	26,459	19
West Counties	10%	10.5%	Fail	19,236	21,264	10
East Counties	15%	7.6%	Pass	6,589	7,544	7
North Counties	15%	10.1%	Pass	5,243	5,781	8
Knox-Blount	15%	3.6%	Pass	18,815	19,543	8
NW Counties	20%	12.6%	Pass	2,367	2,663	8

Figure 14 plots the difference between the model volumes and traffic counts. It also displays the line of fit and coefficient of determination (R^2). The TNMUG standard for R^2 is 0.88. The model clearly exceeds this at a value of 0.95.

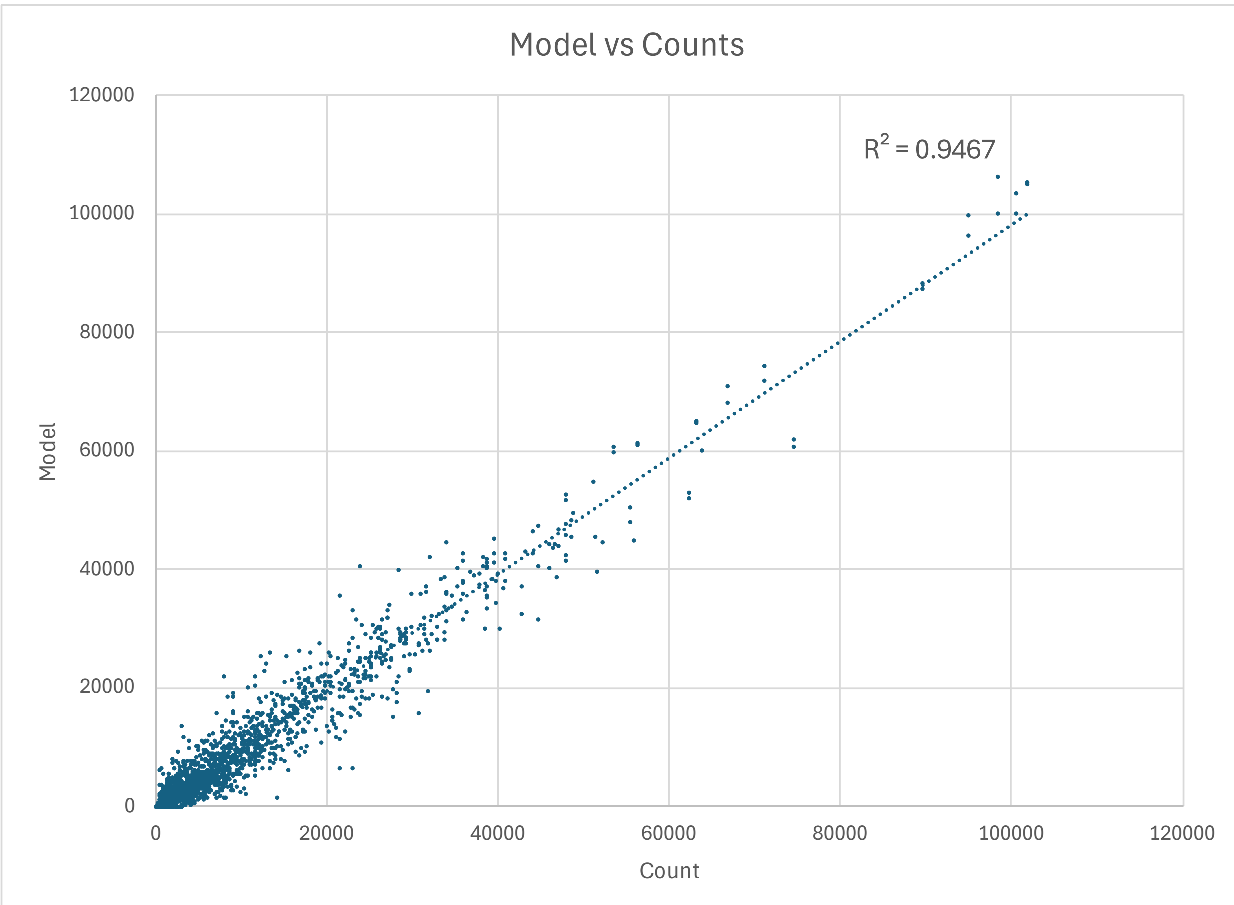


Figure 15. Scatterplot of Model Volumes versus Traffic Counts

Table 17 compares the model to the TNMUG standards for root mean square error. The Percent Root Mean Square Error (% RMSE) is used in addition to percent error and is the traditional and perhaps the single best overall error statistic for comparing loadings to counts. It has the following mathematical formulation:

$$\%RMSE = \frac{\sqrt{\frac{\sum(Count - Loading)^2}{Number\ of\ Observations}}}{Average\ Count} \times 100$$

The model meets the TNMUG standard for Acceptable for all categories and exceeds the Preferred for several categories and for the model overall.

Table 17. Root Mean Square Error (RMSE) Standards

Classification	Standard		Model Value	Pass / Fail	Average Count	Average Modeled	Number of Observations
Freeways	20%		18.4%	Pass	17,376	17,576	447
Major Arterials	35%		21.1%	Pass	19,805	20,412	231
Minor Arterials	50%		31.2%	Pass	10,825	9,867	370
Collectors	60%		58.6%	Pass	3,688	3,300	1,209
Volume Group	**Acceptable**	**Preferred**	**Model Value**	**Pass / Fail**	**Average Count**	**Average Modeled**	**Number of Observations**
0 – 4,999	100%	45%	71.9%	Pass	2,217	2,319	849
5,000 - 9,999	45%	35%	39.6%	Pass	7,192	6,876	395
10,000 - 14,999	35%	27%	29.4%	Pass	12,118	11,884	194
15,00 - 19,999	30%	25%	21.8%	Pass	17,178	17,264	118
20,000 - 29,999	27%	15%	20.2%	Pass	24,632	23,746	162
30,000 - 49,999	25%	15%	11.3%	Pass	38,186	37,366	98
50,000 - 59,999	20%	10%	11.0%	Pass	53,864	52,114	11
60,000+	19%	10%	7.1%	Pass	81,446	80,908	21
All	45%	35%	28.8%	Pass	10,355	10,178	1,848

The model meets all of the assignment validation standards set forth *Minimum Travel Demand Model Calibration and Validation Guidelines for State of Tennessee* with the exception of one screenline which is very close to the standard and may be attributable to small errors in the counts. The 2022 base year model performs very similarly, but perhaps just slightly better than the 2018 model (28.8% vs 31.3% RMSE, 0.95 vs 0.94 R^2) which was considered well validated. It is reasonable to conclude that the model is well calibrated and validated by observed traffic counts.

Finally, as an additional check, total Vehicle Miles of Travel (VMT) by functional classification from the model for the base year 2022 was compared to actual FHWA Highway Performance Management System (HPMS) data. Table 18 shows that the model is reasonably replicating total traffic and only minor adjustments will need to be utilized for the on-road mobile source emissions analyses for transportation conformity determinations.

Table 18. Model VMT versus HPMS VMT for Base Year 2022

	Rural Int	Rural Principal Arterial	Rural Minor Arterial	Rural Major Collector	Rural Minor Collector	Rural Local	Urban Int	Urban Freeway	Urban Principal Arterial	Urban Minor Arterial	Urban Major Collector	Urban Minor Collector	Urban Local	Total
ANDERSON HPMS	471,999	36,077	-	163,454	73,452	56,613	152,673	-	741,200	278,791	110,751	67,115	462,210	2,614,336
ANDERSON Model	481,397	29,543	-	138,741	11,320	6,005	156,492	-	732,056	258,945	81,154	36,067	13,366	1,945,087
HPMS Factor	0.98	1.22	N/A	1.18	6.49	9.43	0.98	N/A	1.01	1.08	1.36	1.86	34.58	1.34
BLOUNT HPMS	-	220,214	102,428	73,748	37,785	112,124	95,656	39,187	1,121,995	517,890	289,484	213,705	743,306	3,567,522
BLOUNT Model	-	247,432	112,740	71,381	26,051	17,321	95,798	42,598	1,125,981	472,064	189,590	151,843	21,383	2,574,183
HPMS Factor	N/A	0.89	0.91	1.03	1.45	6.47	1.00	0.92	1.00	1.10	1.53	1.41	34.76	1.39
HAMBLEN HPMS	345,793	19,066	-	54,452	45,409	55,520	38,626	-	794,225	234,371	153,033	29,807	299,739	2,069,041
HAMBLEN Model	403,524	2,049	-	61,762	15,305	1,953	26,574	-	702,425	204,169	101,398	9,776	11,876	1,540,811
HPMS Factor	0.86	8.82	N/A	0.88	2.97	28.42	1.45	N/A	1.13	1.15	1.51	3.05	25.24	1.34
JEFFERSON HPMS	1,547,244	20,930	359,499	220,566	137,452	148,336	33,266	-	165,287	91,143	17,147	6,276	49,185	2,796,331
JEFFERSON Model	1,588,236	-	432,327	329,280	95,722	11,061	42,042	-	188,018	86,198	13,661	3,605	2,500	2,792,648
HPMS Factor	0.97	N/A	0.83	0.67	1.44	13.41	0.79	N/A	0.88	1.06	1.26	1.74	19.67	1.00
KNOX HPMS	684,474	-	96,594	115,954	115,223	126,976	6,304,386	124,458	2,519,910	2,582,889	796,257	711,990	3,458,742	17,636,853
KNOX Model	647,239	-	107,893	103,803	91,804	20,865	5,685,272	95,468	2,503,585	2,140,622	652,935	553,879	236,561	12,839,927
HPMS Factor	1.06	N/A	0.90	1.12	1.26	6.09	1.11	1.30	1.01	1.21	1.22	1.29	14.62	1.37
LOUDON HPMS	461,656	134,626	73,623	46,462	61,973	53,767	793,014	-	279,284	275,349	60,456	59,552	199,024	2,498,786
LOUDON Model	510,227	167,569	113,018	60,485	22,669	-	908,837	-	277,182	290,461	33,061	21,696	326	2,405,532
HPMS Factor	0.90	0.80	0.65	0.77	2.73	N/A	0.87	N/A	1.01	0.95	1.83	2.74	610.78	1.04
ROANE HPMS	330,047	64,347	80,987	58,101	56,102	64,632	701,249	-	362,229	205,383	27,032	46,294	124,699	2,121,102
ROANE Model	343,291	68,956	87,644	54,487	11,902	-	687,259	-	410,112	152,854	20,541	22,561	17,611	1,877,218
HPMS Factor	0.96	0.93	0.92	1.07	4.71	N/A	1.02	N/A	0.88	1.34	1.32	2.05	7.08	1.13
SEVIER HPMS	-	221,771	527,198	184,606	163,796	542,714	371,369	-	1,352,602	231,582	273,622	54,448	684,574	4,608,282
SEVIER Model	-	221,683	567,606	193,271	54,572	48,421	360,311	-	1,118,487	325,371	196,290	26,825	27,324	3,139,162
HPMS Factor	N/A	1.00	0.93	0.96	3.00	11.21	1.03	N/A	1.21	0.71	1.40	2.03	25.05	1.47

	Total Interstate	Total Principal Arterial	Total Minor Arterial	Total Major Collector	Total Minor Collector	Total Local
ANDERSON HPMS	624,672	777,277	278,791	274,205	140,567	518,823
ANDERSON Model	637,889	761,599	258,945	219,896	47,388	19,371
HPMS Factor	0.98	1.02	1.08	1.25	2.97	26.78
BLOUNT HPMS	95,656	1,342,209	620,318	363,232	251,490	855,430
BLOUNT Model	95,798	1,373,413	584,804	260,971	177,894	38,704
HPMS Factor	1.00	0.98	1.06	1.39	1.41	22.10
HAMBLEN HPMS	384,419	812,291	234,371	207,485	75,216	355,259
HAMBLEN Model	430,099	704,474	204,169	163,159	25,081	13,830
HPMS Factor	0.89	1.15	1.15	1.27	3.00	25.69
JEFFERSON HPMS	1,580,510	186,217	450,642	237,713	143,728	197,521
JEFFERSON Model	1,630,278	188,018	518,525	342,940	99,327	13,561
HPMS Factor	0.97	0.99	0.87	0.69	1.45	14.57
KNOX HPMS	6,988,860	2,519,910	2,679,483	911,211	827,213	3,585,718
KNOX Model	6,332,511	2,503,585	2,248,515	756,739	645,683	257,426
HPMS Factor	1.10	1.01	1.19	1.20	1.28	13.93
LOUDON HPMS	1,254,670	413,910	348,972	106,918	121,525	252,791
LOUDON Model	1,419,064	444,751	403,478	93,547	44,366	326
HPMS Factor	0.88	0.93	0.86	1.14	2.74	775.79
ROANE HPMS	1,031,296	426,576	286,370	85,133	102,396	189,331
ROANE Model	1,030,550	479,068	240,498	75,029	34,462	17,611
HPMS Factor	1.00	0.89	1.19	1.13	2.97	10.75
SEVIER HPMS	371,369	1,574,373	758,780	458,228	218,244	1,227,288
SEVIER Model	360,311	1,340,170	892,977	388,561	81,397	75,744
HPMS Factor	1.03	1.17	0.85	1.18	2.68	16.20